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A RAND
GRADUATE SCHOOL
DISSERTATION

The Effect of Defense Spending on the Trade Performance of High-Technology Industries

Loren Yager

THE RAND GRADUATE SCHOOL
FOUNDED 1970
CALIFORNIA

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Published 1992 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

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N-3408-RGSD

The Effect of Defense Spending on the Trade Performance of High-Technology Industries

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The original version of this study was prepared as a dissertation in June 1991 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Carl R. Neu (Chairman), Eugene Gritton, and John Koehler.

PREFACE

This study is submitted as a dissertation to the RAND Graduate School in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Policy Analysis. The study describes the results of a research project aimed at determining whether the sharp increase in defense spending in the late 1970s and early 1980s played a role in the trade performance of U.S. high-technology industries.

The study's findings should be of interest to persons concerned with the trade and defense policies of the United States.

SUMMARY

Defense spending is often cited as a factor which influences the performance of particular industries. This study examines the large increases in U.S. defense spending during the late 1970s and early 1980s to determine whether these changes affected the trade performance of U.S. high-technology industries. The U.S. surplus in high-technology trade decreased sharply from 1980 until 1986, when it recorded a small deficit for the year.

The research approach was to identify "defense-competing" industries—industries that use many of the same scarce inputs as the defense industry, and must compete with the defense industry for those inputs. Large increases in defense spending might create pressure for higher prices for scarce inputs, and result in higher costs for defense-competing industries in the United States. The focus of this study is on labor inputs, since unlike intermediate products, additional supplies of labor do not readily flow from foreign sources to the United States. Therefore, domestic—but not foreign—labor costs are likely to increase, and this would raise the costs of U.S. defense-competing industries relative to foreign industries. This foreign cost advantage could potentially lead to lower levels of U.S. exports and higher levels of U.S. imports in the affected industries.

The study suggests that the industries that compete most directly with defense producers for inputs include electronic equipment industries: electronic components, radio, TV, and communication equipment, computers and office machines; machinery industries: metalworking machinery, non-electrical machinery, special industry machinery; and transportation equipment industries: aircraft and parts, other transportation equipment. These are the industries that should have faced the largest increase in costs as a result of the 1980s defense buildup. The order of these industries was relatively insensitive to a variety of assumptions and data sources included in the calculations.

The second step of the research was to develop a measure of trade performance that would highlight the differential performance of sectors exposed to different degrees of competition for scarce inputs. The measure was designed to screen out the influence of factors that affect the trade performance of all sectors (exchange rate changes, for example) leaving the influence of sector-specific factors. The trade performance measures were designed to be sensitive to the changes in trade that would result from a percentage increase in the prices of U.S. exports. Specific criteria were developed to evaluate the trade metrics, and a metric was found that approximately meets these criteria. Using this measure, the industries with the best trade performance over this period include "plastic and rubber

medical supplies," "optical instruments," and "missiles and space vehicles." The list of industries with the poorest trade performance is headed by "iron and steel products," and also includes "service industry machines," "yachts," and "fabricated structural metal products."

The next step of the study involved tests of the relationship between the impact of defense spending and the trade performance of industries. The results provide no evidence that the increase in defense spending contributed to the poor trade performance of high-technology industries. The regression results include both positive and negative coefficients, and none of the t-statistics indicate a statistically significant relationship. Calculations using the trade metric for a variety of years or different sources of data in the defense-competing metric have little impact on the regression results. These results indicate either that no effect of defense spending on trade performance exists, or that the methods were not sensitive enough to measure the effect.

The finding that there is no relationship between the increase in defense spending and the poor trade performance of high-technology industries has important implications. The most obvious is that the poor trade performance of high-technology industries that was observed during the mid-1980s was caused by other factors. Since there was no apparent effect of the sharp increase in spending, a second implication is that benefits from any decreases in spending that may occur during the current period are unlikely. This finding is also relevant to the current discussions about future defense policies. The results indicate that a strategy of performing the research and development but delaying large-scale production until needed is unlikely to negatively affect trade performance of industries, at least in economic circumstances similar to those of the early 1980s.

The study also provided the opportunity to test for positive effects of defense spending. Using data on the percentage increase in sales that were generated by the defense buildup for each industry, a mixed set of results suggest that there may be some positive impacts of defense spending through a mechanism such as economies-to-scale.

A number of interesting follow-on research efforts are suggested by this research. One would be to closely examine the effect of defense spending on wages. A second way to further study the mechanism through which defense spending might affect economic performance is through an examination of the effects of industry price increases on the trade performance of these industries. A third follow-on effort would be to review the data from previous increases in defense spending such as the Vietnam buildup to look for similar effects. Finally, the mixed results of the tests for positive effects of defense spending suggest that there may be

some mechanism by which defense spending might improve trade performance. Further study is necessary to explore the nature and extent of those potential positive effects.

ACKNOWLEDGMENTS

A number of people were instrumental in this effort. Michael Rich and Charles Wolf, Jr., supported the idea from the early stages, and also provided opportunities to present the research to various audiences. David Draper assisted in an early effort that helped get the data analysis started. Other RAND staff members also provided assistance both in the form of comments in the briefings and in supporting services. Committee members Gene Gritton and John Koehler provided comments at key points in the development of the study. I would especially like to thank Committee Chairman C. R. Neu for his invaluable assistance from the inception through the completion of the research.

Finally, I would like to thank Jane Yager, who provided support and encouragement throughout this long project.

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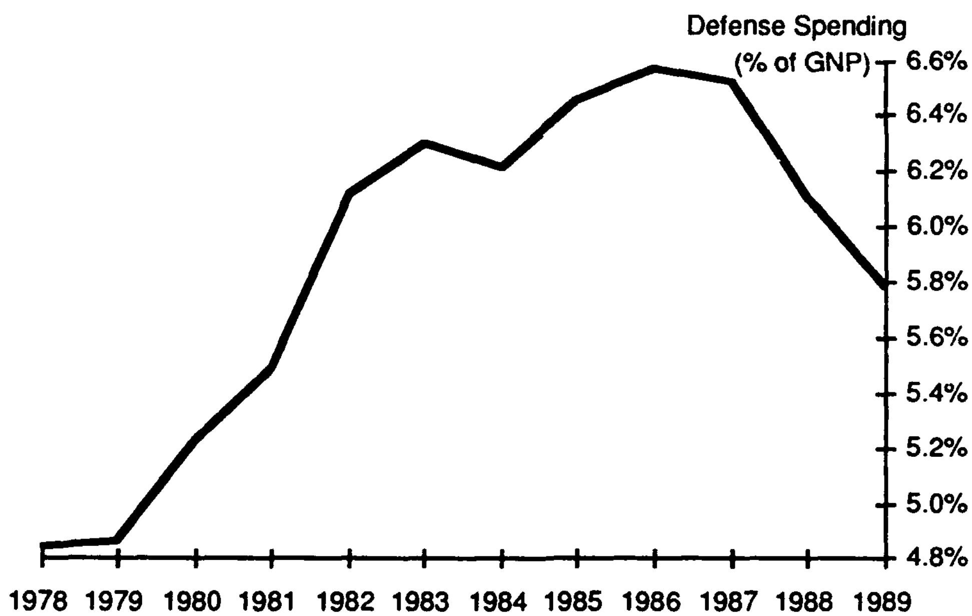
1. INTRODUCTION

There has been a long-standing debate about the effect of defense spending on economic performance, with arguments and evidence provided for both positive and negative impacts. Examples of positive impacts include the technological spin-offs of defense research and development, training of manpower in less-developed countries, etc. On the other hand, critics point to the diversion of scientific and technical personnel or investment capital as examples of negative effects of defense spending. It is not surprising that this debate has been renewed as a result of the sharp increases in U.S. defense spending of the late 1970s and early 1980s (see Fig. 1.1).

Recently, the debate has shifted to the effects of defense spending on high-technology industries.[1] One reason for the changing concern is that high-technology industries have



SOURCE: *1990 Economic Report of the President*, Table C-1.
NOTE: In terms of 1982 dollars, defense spending increased from $171.2 billion in 1980 to $265.2 billion in 1987.

Fig. 1.1—U.S. Defense Spending as a Percent of GNP

[1]For example, see Browne 1988, p. 5; Dumas 1984, p. 133; Markusen 1985, p. 71; M. Smith 1985, Tirman 1984, p. 13; or Ullman 1984, p. 105.

become increasingly important among defense suppliers, and are the industries most likely to be directly affected by defense spending.[2] Another reason for focus on "high-tech" is the perceived importance of these industries to the U.S. economy. The industries that are often described as high-technology industries—electronics, computers, aerospace, etc.—are considered to be largely responsible for the rapid technological development of the last decades of the twentieth century, in the way that steel and autos were responsible for the industrial development of the mid-twentieth century. Technological progress in high-tech industries is seen by many as offering continued growth opportunities, many of which lead to more general increases in productivity in the workplace and improvements in the standard of living. Although these gains in productivity and standard of living accrue not only to the firms or countries responsible for the developments, U.S. policymakers have expressed concern over the type and the speed at which U.S. firms appear to be losing these high-technology markets to foreign producers (see Fig. 1.2).[3] The health of high-tech industries appears to be a common concern in the defense community, where the advances in these industries have given the United States a technological advantage in the production of weapons and other defense systems. The long-term ability of the U.S. economy to finance the nation's security requirements is also a feature of this debate.[4]

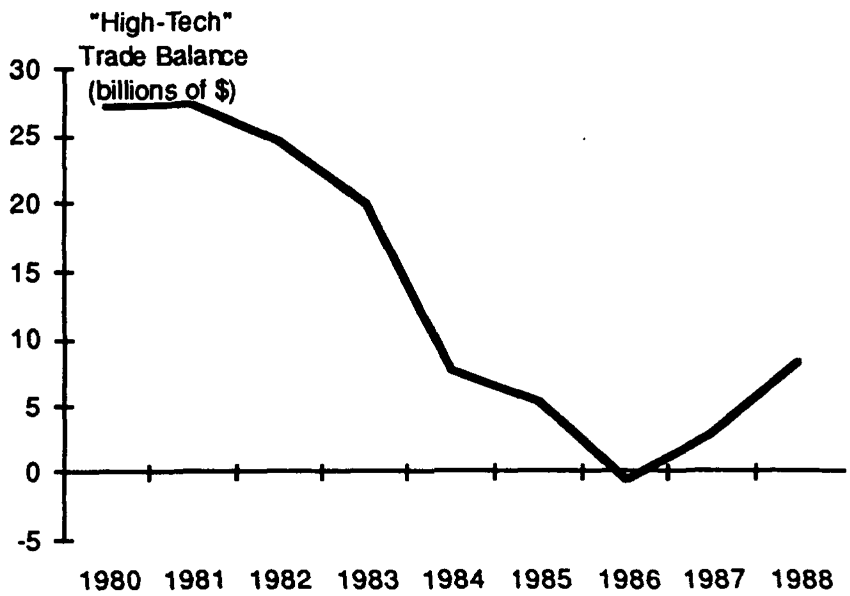
The causes of this decline in the trade performance of high-technology industries are poorly understood. Certainly, the strength of the U.S. dollar and other macroeconomic factors during the 1980s have had an impact on the trade performance of the high-technology sector, as on all other sectors. However, it is important to determine whether sector-specific factors have contributed to the poor trade performance of U.S. high-technology industries. The focus of this study is on one possible explanation: the sharp increase in defense spending.

Defense spending as a percent of gross national product (GNP) increased sharply during the early 1980s, peaking in 1986 at approximately 6.6 percent of GNP. From 1980 to 1986, the U.S. surplus in high-technology trade declined sharply. After defense spending peaked in 1986 as a share of GNP, the high-technology trade surplus began to recover. These contrasting trends are illustrated in Fig. 1.3.

[2]Dumas 1977, p. 20; and Tirman 1984, p. 16.

[3]Defense Science Board Report, 1988.

[4]See for example P. Kennedy 1987; Oden 1988, p. 36; and Sorensen 1988, p. 163.



SOURCE: U.S. Department of Commerce, Office of Trade and Investment Analysis.

NOTE: Trade balance for the industries included in the "DOC 3" definition of high-technology. DOC 3 identifies high-technology industries using the value of applied Research and Development funds embodied in both direct and indirect inputs. The total trade (in current dollars) of high technology products increased from $82 billion in 1980 to $200 billion in 1988.

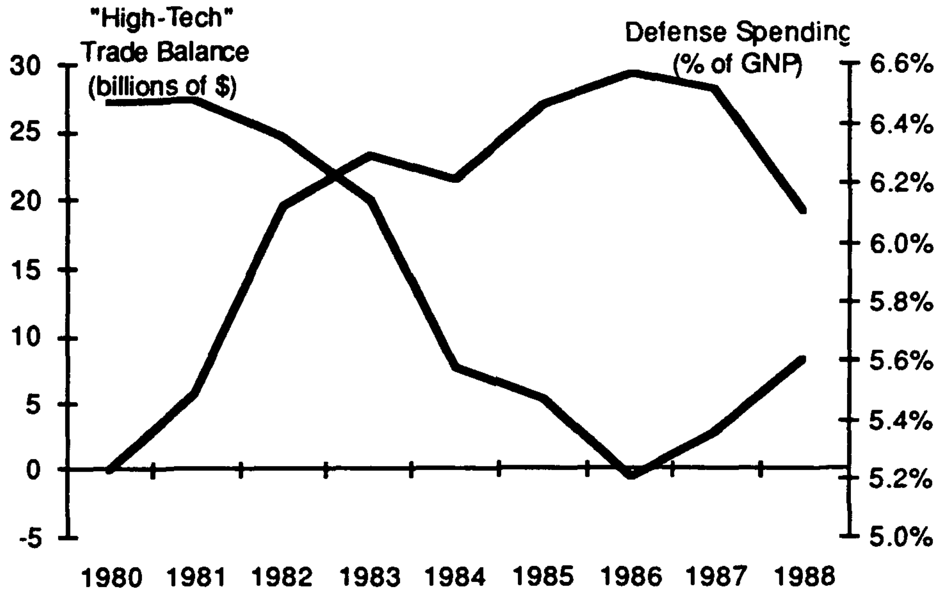
Fig. 1.2—U.S. Trade in High-Technology Products

Of course, the fact that defense spending and the high-technology trade balance exhibit contrasting trends during this period could be purely coincidental. The purpose of this research is to explore whether this negative relationship is more than a chance occurrence.

PREVIOUS RESEARCH ON DEFENSE SPENDING AND ECONOMIC PERFORMANCE

Studies of defense spending typically identify a particular productive resource, and describe how defense spending either enhances or degrades the contribution of this resource to the economy. For example, in less-developed countries, it has been hypothesized that the training provided by military service has a long-term positive impact by enhancing the labor force.[5] The opposite argument has been made for developed countries, that defense production has drawn scarce science and engineering personnel from commercial to defense

[5]Benoit 1973, p. 32.



SOURCE: See Figs. 1.1 and 1.2.

Fig. 1.3—Contrasting Trends

production,[6] with a negative effect on the commercial industries. Similar arguments can be made about the effect of defense spending on the capital stock.[7] For example, it is possible that capital equipment produced for the military might later be made available at a low cost to commercial users, leading to a larger capital stock than would have developed without the defense spending. On the other hand, defense spending may also divert resources away from investment, and thus have a negative impact on the capital stock.

Although it is relatively easy to suggest ways in which defense spending might enhance or degrade productive inputs, it is much more difficult to demonstrate that these changes actually have a measurable impact on some aspect of economic performance. Defense spending for most countries is a relatively small percentage of GNP, and therefore, sensitive measures are necessary to detect the effects of defense spending.[8] In addition, defense spending is made up of a large number of different elements, each of which may have a different impact on economic performance.[9] Finally, there are other factors affecting

[6]Dumas 1986.
[7]R. Smith 1980, p. 20.
[8]Haveman 1990, p. 12.
[9]Chan 1985, p. 422.

economic performance at any given time, so it is difficult to isolate the effect of defense spending.[10]

Two types of methods that have commonly been used to test for possible effects of defense spending are cross-country comparisons and longitudinal comparisons. Cross-country comparisons are used to test for association between the level of defense spending and economic growth across a number of countries. For example, Emile Benoit found evidence that in developing countries, defense spending may have had a positive impact on economic growth.[11] Since that time, other researchers have found a negative relationship between defense spending and economic growth in developing countries.[12] Cross-country studies of developed countries have tended to find a negative association, if any, between defense spending and economic growth.[13] However, these cross-country approaches are subject to a variety of problems with regard to attributing the differential performance of nations to defense spending and not to other factors.

Longitudinal analyses have also been used to try to capture the impacts of defense spending on economic growth.[14] These methods are designed to evaluate the association between defense spending and economic performance in a single country over a period of years. For example, output might be expected to increase immediately as a result of increases in defense spending, but other impacts such as a "training effect" or an "investment effect" may take longer to develop. Therefore, the type of lag that would be expected from the defense spending to the economic performance depends upon the assumed mechanism by which defense spending will affect the economy. The longitudinal analyses must also isolate the changes in economic performance attributable to defense spending from other factors that may have changed over the period.

The methods used in this study combine certain aspects of the cross-country and longitudinal designs. This study uses a type of cross-sectional design, but in this case industries rather than countries are the unit of analysis. Defense spending has a differential impact on industries, so it should be possible to compare industries to determine whether there is an association between the impact of defense spending on an industry and the industry performance. As in the longitudinal analyses, economic performance is measured at

[10]Adams 1987, p. 2.
[11]Benoit 1973.
[12]See Deger 1983, p. 352; or Faini 1984, p. 487.
[13]See Cappelen 1984; or R. Smith 1983, p. 15.
[14]R. Smith 1980, p. 31.

different points in time. This study of industry performance over a specific time period is designed to study the effects of a single large change in defense spending.

THE THEORY BEHIND THIS RESEARCH

Consider what might be called "defense-competing" industries. These are industries producing civilian goods which use many of the same inputs as industries producing defense goods, and therefore compete with defense producers for inputs. The commercial aircraft industry is an example of a defense-competing industry. Commercial and military aircraft producers utilize many of the same inputs, from production personnel such as machine tool operators to components such as semiconductor chips. In situations where the price of defense inputs increases, the price of inputs for the commercial aircraft industry would also be expected to increase. Rapid increases in demand for defense products, in combination with a relatively inelastic supply of the productive inputs, would be one situation in which the wages and prices for defense inputs would increase. This situation would presumably lead to increases in costs for "defense-competing" industries.

The diagram in Fig. 1.4 illustrates the likely consequences of an increase in defense spending. The increase in defense spending leads to an increase in demand for both material and labor inputs. Material inputs are commonly available from both domestic and foreign "defense-competing" industries. Since most material inputs are traded on the world market,

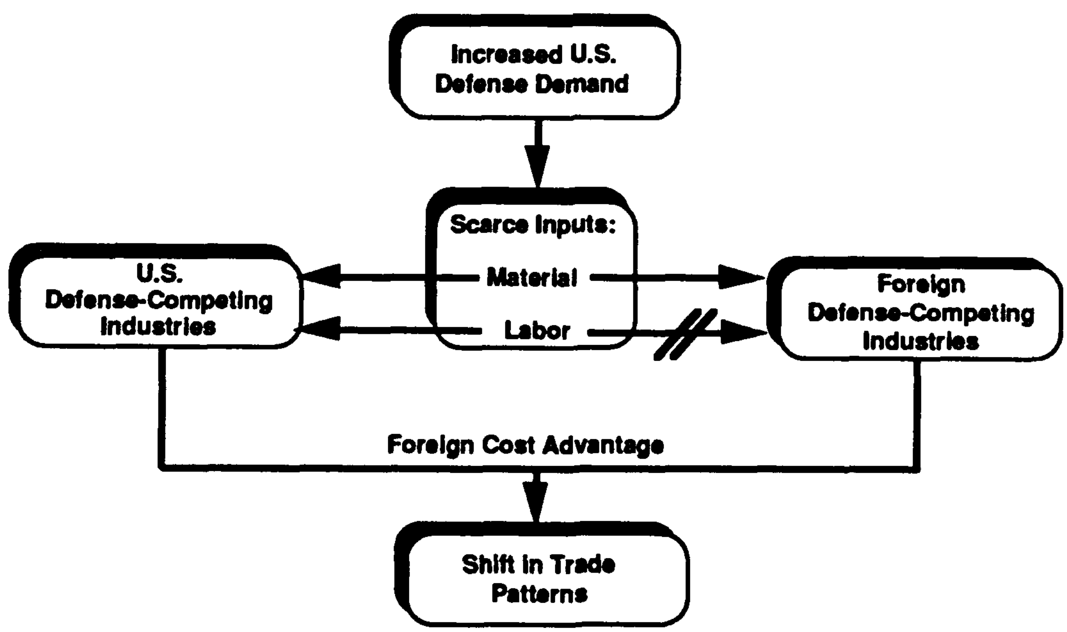


Fig. 1.4—The Theory Behind This Research

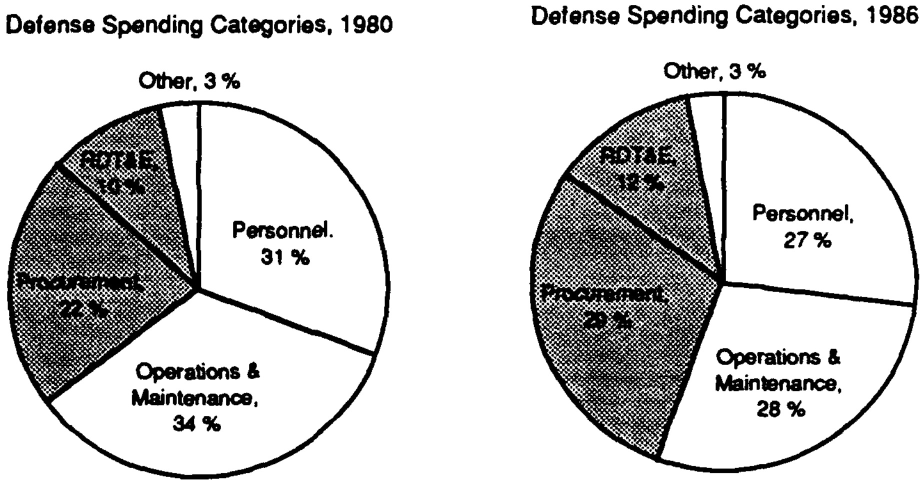
inputs diverted from both domestic and foreign sources are available to help supply the defense demand. Under these conditions, a short supply of an input domestically will likely lead to a short supply abroad. Therefore, increases in defense demand are not likely to increase material prices any more for domestic firms than for foreign firms.

However, competition for labor inputs may be different. In the short run, labor inputs do not easily cross borders for a variety of cultural, legal, linguistic, and other reasons. Large increases in defense spending might create pressure for wage increases in certain occupations, and therefore increase the costs of defense-competing industries in the United States. Since additional supplies of labor cannot flow from foreign sources to the United States, foreign labor costs are not likely to increase. This would raise the costs of U.S. defense-competing industries relative to foreign industries, creating a foreign cost advantage, and potentially lead to a shift in trade patterns.

In order to test this theory, it is necessary to compare the trade performance of industries that compete directly with defense industries for labor with the trade performance of industries that do not. The industries that share a large number of scarce labor inputs with the defense producers are likely to face the largest increase in costs as a result of the sharp increase in defense demand. These industries would be expected to be at a relatively large disadvantage with respect to foreign producers. Other industries may have little overlap in terms of their labor requirements with defense producers—a low level of "defense-competitiveness"—and therefore are likely to face relatively little cost disadvantage with respect to foreign producers. Therefore, a comparison of defense-competing with non-defense-competing industries would indicate whether the change in defense spending had an impact on industry performance.

The Composition of the Defense Buildup

Since the purpose of this research is to measure the differential impacts of defense spending on industries, those aspects of defense spending that have the greatest direct impacts on industries are of interest. Virtually all of the Research, Development, Testing and Evaluation (RDT&E) and Procurement categories generate purchases of equipment or technology directly from private industry. Figure 1.5 shows the share of the U.S. defense budget that is accounted for by the Procurement and RDT&E categories, and how this share increased from 1980 to 1986. Purchases from these categories are highly concentrated in a few industries such as aerospace, communications equipment, ordnance, and electronics. These industries employ a large number of skilled workers for design and production tasks, skills which may be in short supply during a rapid increase in demand.



SOURCE: U.S. Budget, 1980 and 1986.
NOTE: The totals in nominal terms for all categories in 1980 and 1986 were $131 billion and $265 billion, respectively.

Fig. 1.5—Major Defense Spending Categories, 1980 and 1986

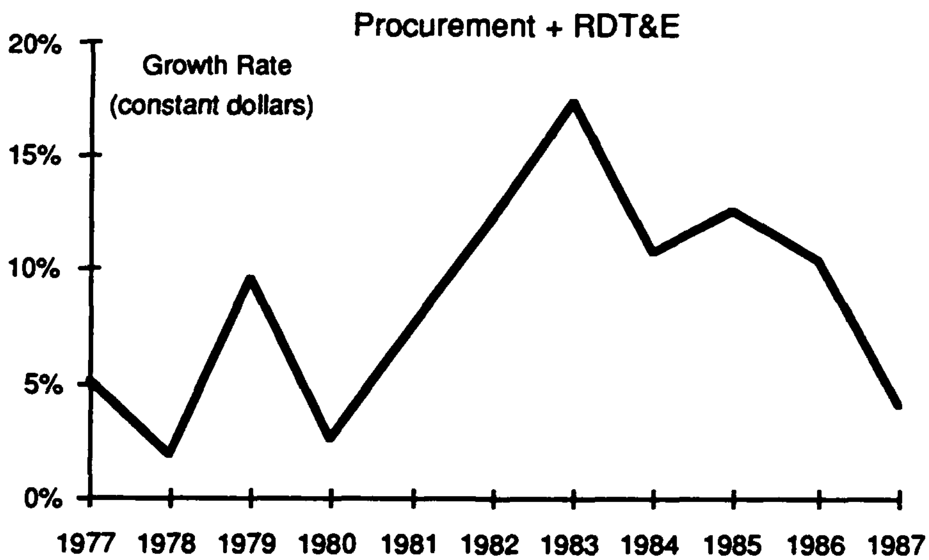
The industry impacts of the Personnel, and Operations and Maintenance (O&M) spending are more evenly distributed across all industries. Increases in spending for Personnel may have some measurable impact on certain broad categories of workers in the labor force, but are unlikely to have much impact on specific industries. This is particularly true since the majority of enlistees do not enter the service with specialized skills, and as a result, the supply of these workers is likely to be more elastic. Payment of employees in the Personnel account also has an impact on industries through indirect purchases of goods and services by those employees and their dependents. However, these indirect purchases are distributed in a less concentrated set of industries than the direct purchases of the Department of Defense, and are unlikely to be substantially different from purchases by workers in other industries.

The Timing of the Defense Buildup

The longitudinal nature of the research design requires identification of a period of change in defense spending. Ideally, this period of study would begin at some point before any significant change in defense spending occurred, and end at the point where the increases in spending had reached a peak. The peak year should be one in which the defense spending was most likely to have led to an increase in costs for scarce defense inputs such as skilled labor. Increases in costs occur when productive inputs, including plant capacity,

intermediate products, and in particular skilled labor, are not available in sufficient quantity at current prices and wages. This situation would result from successive increases in defense spending with no "off-years" for industry to catch up.

Defense spending from 1980 to 1983 appears to have been a period where the increases were rapid and continuous in the Procurement and Research, Development, Testing and Evaluation (RDT&E) categories (Fig. 1.6). After a relatively small increase from 1979 to 1980, the combined spending in Procurement and RDT&E demonstrated increasing growth each year through 1983, peaking at a real-growth rate of nearly 20 percent. The growth rate for spending in the combined Procurement and RDT&E category declined in 1984. For the remainder of this research, the year 1980 will represent the baseline or pre-buildup industry, and the year 1983 will represent the peak year when measurable impacts are most likely to occur. A focus on these categories during this period of sharp increases in demand offers the best opportunity to observe the differential impact of changes in defense spending on industry performance.



SOURCE: U.S. Budget, 1977-1987.
NOTE: From 1980 to 1983, the outlays in these categories increased from $50.5 billion to $71.6 billion in 1982 dollars.

Fig. 1.6—Real Growth Rate of Procurement and RDT&E

RESEARCH APPROACH

The research approach for this project has three major steps, as illustrated in Fig. 1.7. The purpose of the first step is to identify the "defense-competing" industries that may have been most affected by the buildup in defense spending. In a situation of sharply increased defense demand, defense producers will bid up the wages for certain types of workers who are in inelastic supply, thus increasing output to keep up with demand. These increased wages will also increase the costs for defense-competing industries. Industries that utilize many of the same types of workers as defense producers would be expected to face a large increase in costs, while other industries may be relatively unaffected.

In order to estimate this expected increase in costs for each industry, the increases in Procurement and RDT&E outlays from 1980 to 1983 are converted into increases in demand for each of 77 industries. Using both input-output (I-O) tables and a matrix detailing the number of employees by occupation for each industry, the differential impacts of these demand increases on approximately 500 occupational categories are estimated. Using estimates for the elasticity of demand for certain categories of final demand and judgements about the supply elasticity for various occupations, the 77 industries are then ranked according to a metric which represents their expected increase in labor costs.

The second step of the research project involves an examination of the trade performance of U.S. industries. A specific trade performance measure is developed that reflects the changes that occurred within individual import and export industries. The trade performance measure is designed to be largely insensitive to the factors that influenced overall trade, such as the value of the dollar, differential growth rates in the major countries around the world, etc. The measure is based on rates of growth of imports and exports for

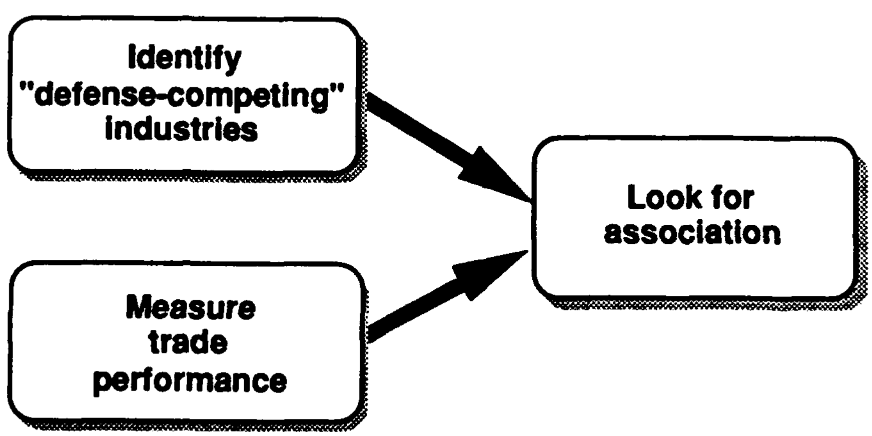


Fig. 1.7—Research Approach

three-digit Standard Industrial Classification (SIC) import and export categories. The trade performance measure is also computed from the base period of 1980 through a variety of endpoint years to allow for any potential lagged effects of the defense spending on trade performance.

The third step of the research project involves testing the relationship between the impact of defense spending and the trade performance of industries. A series of analyses are performed to determine whether any association exists between the defense-competing and trade performance measures. If defense spending has a negative impact on the trade performance of industries, the results of the research would indicate a negative relationship between the level of defense-competing metric and the trade performance metric. On the other hand, if there is no significant relationship between the trade and defense-competing measures, this suggests that competition for skilled labor did not affect the trade performance of industries. Since the high-technology industries turn out to be among the highest defense-competing industries, the strength of this relationship will also indicate whether the poor trade performance of high-tech industries is related to defense spending.

OVERVIEW OF THE STUDY

The organization of this study follows closely from this research approach. Section 2 of the study describes the methods used to identify defense-competing industries. It includes the methods developed to estimate the added costs that are likely to occur as a result of the defense buildup. Results are provided for a series of calculations which incorporate different data sources and assumptions.

Section 3 of this study describes the trade performance measure. This section includes a discussion of the criteria that were developed for the purpose of choosing among the ways in which trade performance can be defined. The performance measure which meets these criteria is described, and the trade performance results for a range of years are compared in the section.

Section 4 provides a series of regression results between the defense-competing measures described in Section 2 and the trade performance measure described in Section 3. Both plots and statistical results are used to describe and test the level of association between the measures. This section also describes the broader assumptions underlying the research.

The final section of this study provides a discussion of the findings and their implications.

2. IDENTIFYING DEFENSE-COMPETING INDUSTRIES

The impact of defense spending, and especially the direct purchases of the Department of Defense, are not uniformly distributed across all sectors of the economy. Most of the direct purchases are concentrated in industries such as aircraft and electronics. However, the indirect purchases of the Department of Defense are more widely distributed among industries. The U.S. economy is enormously complex, and increased defense demands on one industry may have consequences for other industries even if the Defense Department buys nothing directly from these other industries. While defense spending constitutes a major component of the total demand for goods and services in the U.S. economy, it is not so large that its economic consequences are easily observed through general macroeconomic analyses.[1] Neither are macroeconomic concerns usually foremost in the minds of policymakers. More often, policymakers focus their attention on how defense spending affects particular industries or regions. For all of these reasons, it would be useful to develop a general framework for identifying sectors of the U.S. economy where the consequences of changes in defense spending—either up or down—are most pronounced.

As a step toward such a framework, this study uses the concept of "defense-competing" industries. These are industries that compete with defense production in the sense that they use as inputs many of the same scarce resources that are required for defense production. When defense production increases, these resources may be in short supply, their prices may rise, and defense-competing industries may face higher costs. The aim has been to devise a practical measure of the degree to which various industries compete with defense production, and thus a measure of how much the production costs of these industries may be affected by a change in defense spending.

Two considerations are important in defining such a metric. The first is to determine which industries use the same inputs that are needed for defense production. Since all defense production does not require the same set of inputs, the set of defense-competing industries will not be constant through time but will depend on the composition of a particular change in defense spending. A surge in defense spending driven largely by increased funding for exotic weapon systems (the Strategic Defense Initiative, the B-2, etc.) will require different inputs than a major buildup of conventional ground forces (tanks, artillery, etc.). An industry that may face sharply changed competition from some kinds of

[1]See Adams 1987, p. 3; de Haan 1987, p. 91; and Haveman 1990, p. 12.

defense production may be relatively unaffected by others. This suggests that the metric for defense competitiveness must be flexible enough to reflect the consequences of changes in the composition of defense spending.

The second consideration is whether the inputs needed for defense production and for production in potentially defense-competing industries are limited in supply. A particular industry may use many inputs that are also used in defense production. If these inputs are in plentiful supply, or if the supply of these inputs could be expanded easily in response to a relatively minor increase in prices, then an increase in defense spending will probably have only a minor impact on the costs of the industry in question. Similarly, if a small price rise discourages the use of a particular input in other industries, increased defense demand is unlikely to lead to a substantial cost increase for industries that continue using that input. Thus, the metric has to take some account of the scarcity of particular inputs. In the usual economic jargon, the price elasticity of the supply-of and the demand-for inputs must be considered.[2]

A LABOR-CONSTRAINED ECONOMY

In this research, the focus is on an economy that is constrained principally by the supply of labor. In the short run, of course, economies face additional constraints: the capacity of existing plants, the supply of raw materials, etc. In the longer run, these latter constraints can be eased. New factories can be built, intermediate products can be imported, and so on. In the very long run, labor constraints can also be eased. New workers can be trained, immigration laws can be changed, etc. But it seems plausible to postulate that, in the United States at least, labor constraints will be longer lasting than most other constraints. A model based on inelastic supplies of labor may provide a reasonable approximation of what will happen over some middle run—say, five years or so—as a consequence of increased defense spending.

A model based on inelastic labor supplies may be particularly relevant for the consequences of defense spending on patterns of international trade. Many of the inputs required for defense production are traded internationally: electronic components,

[2]Price elasticity is a measure of how much the supply-of or the demand-for a good is affected by a change in its price. Elasticities are expressed as a ratio of percentage changes. If a good has a supply price elasticity of 2, for example, the volume of the good supplied will rise by 2 percent every time the price of the good goes up by 1 percent. Demand for a good with demand price elasticity of –3 will decline by 3 percent for every 1 percent increase in its price. Economists usually speak of "own-price elasticities": the amount that supply or demand of a good changes in response to a change in its own price, and "cross-price elasticities": the amount that supply or demand changes in response to a change in the price of some other good.

specialized metals, etc. If increased defense spending strains the domestic supply of such an input, some domestic users of that input will turn to foreign suppliers. If trade is perfectly free—perfect information, no tariffs or export restrictions, negligible shipping costs, etc.—an increase in defense spending will raise prices of traded inputs by the same amount in all countries. Since users of these inputs are equally disadvantaged regardless of location, there is no reason to expect that users in one country will gain a competitive advantage over users in other countries. Since trade is never perfectly free, increases in U.S. defense spending might raise the prices of some inputs more in the United States than abroad. Nevertheless, trade in many commodities and intermediate products is extensive, and the free trade model, particularly with respect to U.S. imports, may be an acceptable approximation of reality. Certainly, the free trade model is more applicable to material inputs than to labor inputs.

CONSIDERATIONS IN DEVELOPING A METRIC

A goal of this study is a relatively simple, easily applied metric to identify the industries likely to be most affected by changes in defense spending. Even fairly simple metrics generate significant data and computational requirements. In particular, three factors were considered in developing the desired metric: the level of detail of the data, the timing of data, and computational feasibility. The first two considerations are related to the fact that the metric must be based on routinely available data. As the economy is divided into increasingly specific sectors, the information required for calculating the metric of defense competitiveness increases rapidly. As a result, there is an important data constraint. While it may be possible to estimate *de novo* requirements or elasticities for a small number of industries, doing so for the many industries required for a usefully detailed analysis of the effects of defense spending is out of the question. Other data limitations were imposed by the need to be able to convert results from one industry classification system to another. As a result, it was not possible to use the most detailed (approximately 500 industry) input-output tables, relying instead on the 77 industry table.[3] However, it was possible to utilize the full occupational detail of the National Occupational Employment Matrix.[4] This matrix contains estimates of the occupational employment for each of 500 occupations in 265 industries.

A second consideration is that the data are available for the years appropriate to the analysis. Because this study concerns events that occurred between five and ten years ago,

[3]The input-output tables are produced by the Bureau of Economic Analysis, U.S. Department of Commerce. The tables are based on detailed industry information collected by the Census Bureau.

[4]The employment matrix is produced by the Bureau of Labor Statistics (BLS), U.S. Department of Labor. Information for the matrix is collected by the BLS in cooperation with state employment agencies.

most of the statistical data required are now available. For example, the 1980 and 1983 defense budget data and input-output tables are all available. On the other hand, the National Occupational Employment Matrix is produced only periodically, and in this case the 1986 tables were the best available to represent the employment patterns in 1983. Similarly, the Defense Translator Tables are produced only periodically, but the most recent tables were appropriate for this analysis. Available estimates of final demand elasticities represent a number of different time periods.[5]

An additional concern is computational feasibility. Despite advances in computing power, some kinds of detailed economic analyses are still not computationally feasible. The ideal approach to calculating the effects of defense spending on various sectors of the economy is general equilibrium analysis. This type of analysis incorporates the effects of every change in every industry on every other industry, and on the incomes and spending of consumers. Unfortunately, general equilibrium models of the economy typically do not have analytic solutions. These models can be solved only by very demanding numerical techniques. While so-called computable general equilibrium models have been applied to some real-world policy questions, the computational requirements of models with enough detail are beyond the resources available for this study. More importantly, it seems unlikely that the advantages of using these ideal models are sufficient to justify the costs of implementing them.

CALCULATING A DEFENSE-COMPETING METRIC

The metric of interest for this research will estimate the percentage increase in price for the output of each industry that is likely to occur as a result of defense spending.[6] These price increases result from varying degrees of competition with the defense producers for scarce labor resources. The metric incorporates information on the size of the defense buildup, the inter-industry structure of the economy, the employment patterns of industries, and the elasticity of demand for industry output. A summary of these calculations is provided below.[7]

Annual defense budgets provide information on changing budget levels for specific defense programs. To make this information suitable for further analysis, it is necessary to convert changes in spending on specific defense programs into changes in defense demand for

[5]Results were calculated for a range of elasticity estimates as part of the sensitivity analysis.

[6]For the development of the defense-competing metric, see Appendix A.

[7]The Appendices provide a more detailed description. Appendix B describes the data sources, and Appendix C provides the details of the calculations.

the output of particular industries. This conversion is accomplished through the use of the Defense Translator Tables, represented by the first "filter" in Fig. 2.1. These Translator Tables are produced for the Office of the Secretary of Defense as a major component of the Defense Economic Impact Modeling System.[8] The tables divide each of the spending categories of the Defense Budget into one of approximately 400 SIC categories. These demand increases for each budget category are then added to produce direct demand increases for each of 400 SIC industries. These direct demand increases indicate the additional direct purchases in each industry generated by industry sales to the Defense Department from 1980 to 1983.[9]

The second filter in Fig. 2.1 indicates that the Total Requirements Input-Output Table is used to calculate the total (direct and indirect) demand increases that result from increased defense purchases. The total demand increases include the additional purchases generated by the purchases of the Department of Defense. These indirect purchases might include industry spending on inputs such as machinery, office equipment, and intermediate materials required to fulfill the direct requirements.[10] The results of this first round of calculations indicate the industries that are likely to experience the largest increases in demand as a result of the increase in defense spending.

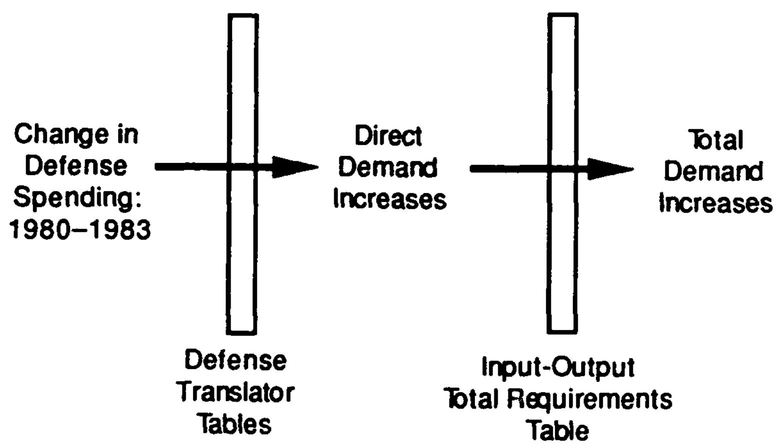


Fig. 2.1—Estimating Demand Increases

[8]Examples of these tables are provided in Appendix B.

[9]These calculations produce the vector of values d_k in equation 10 in Appendix A, the increase in output that results from defense spending for each of 77 input-output industries.

[10]In the terms of equation 1b in Appendix A, this is multiplying the vector of changes in defense spending by the total requirements matrix $(I - A)^{-1}$.

The first filter represented in Fig. 2.2 is the labor requirements matrix.[11] This matrix converts the increases in industry demand into increases in demand for particular kinds of labor. The intermediate result is the number of additional workers in each of approximately 500 occupations that will be necessary to meet the demand generated by the increase in defense spending.[12]

However, as indicated on the right side of Fig. 2.2, the wage increases that result from the increases in occupational demand depend on the type of occupation. Since supply elasticities for each of the 500 occupations are not available, the occupations were divided into groups with infinitely elastic or completely inelastic supply. Infinitely elastic supply was assumed for those occupational groups where entry into the occupation is not limited by a specific skill or educational requirement. For those occupations where entry is limited by some skill or educational requirement,[13] the increase in demand is expected to lead to competition for a limited supply of workers, and wage increases are likely.

The extent of the wage increases required to draw the necessary number of workers from production for civilian final demand is also calculated. These increases depend upon the number of those workers in civil production and the characteristics of demand for their

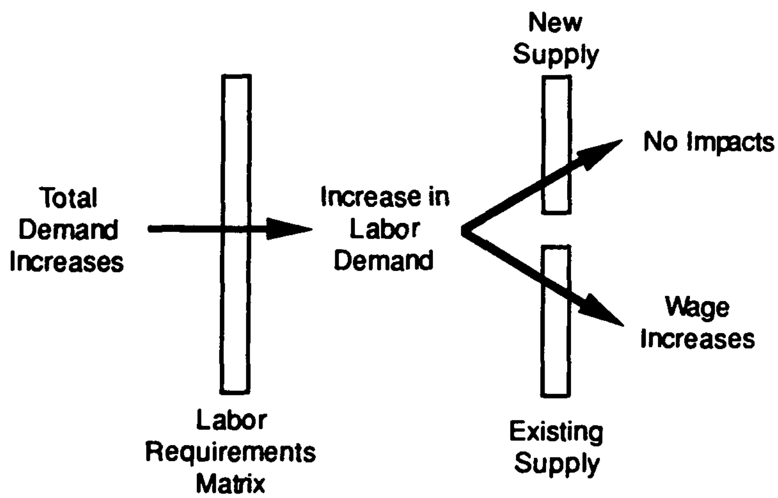


Fig. 2.2—Estimating Wage Increases

[11]Matrix **B** in equation 2a in Appendix A.

[12]This intermediate result is represented by the numerator $\Sigma C_{jk}d_k$ of the fraction in equation 10 in Appendix A.

[13]The methods used to identify the supply-constrained occupations are described in detail in Appendix B. The list of supply-constrained occupations is provided in Table B.7.

output. If a large number of workers are needed and only a few are employed in non-defense industries, this will lead to competition for these workers and a large increase in wages. The calculations also incorporate elasticities of final demand. If the workers required for defense production are employed in industries characterized by inelastic demand, larger price—and therefore wage—increases would be required to reduce demand for this industry output and free up the necessary labor.[14]

The final step in estimating the defense-competing measure involves a summation of the various wage increases within each of the 77 input-output industries weighted by the number of workers within each industry. Fig. 2.3 illustrates these steps. Both the labor requirements matrix and the input-output tables are necessary since the defense-competing metric measures the increased costs due to all wage increases, including those that result from the direct and indirect demand increases due to defense spending.[15]

RESULTS OF THE CALCULATIONS

Table 2.1 is a ranking of industries based on the level of the defense-competing metric. Based on these calculations, the "electronic components" industry is the industry that should have faced the largest percentage increase in labor costs as a result of the increase in defense spending from 1980 to 1983. Other industries that appear at the top of the list include "metalworking machinery," "non-electrical machinery," and "aircraft and parts."

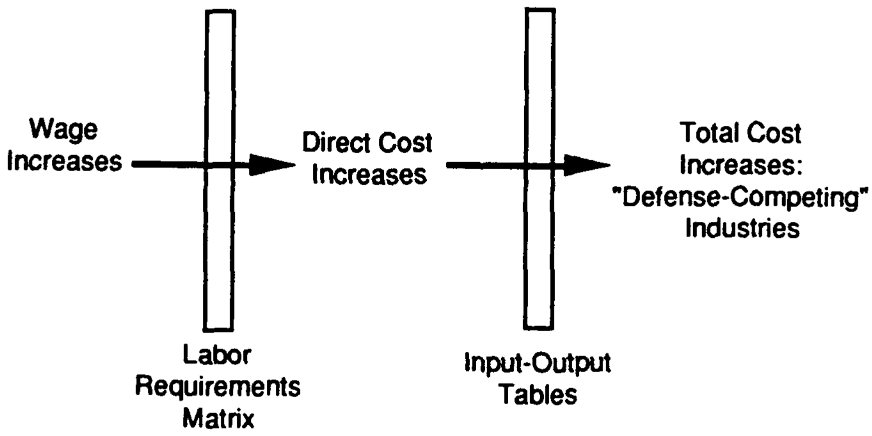


Fig. 2.3—Identifying Defense-Competing Industries

[14] This result is represented as the entire fraction in equation 10 in Appendix A.

[15] These steps are accomplished by the $\sum C_{ji}$ component of equation 10 in Appendix A.

Table 2.1

Defense-Competing Industries

Metric	Industry Title
6.66	Electronic Components
6.56	Metalworking machinery
5.88	Misc. Nonelectrical Machinery
5.46	Aircraft and Parts
5.03	Radio, TV, and Communication equip.
5.02	Other Transportation Equip.
4.91	Special Industry Machinery
4.86	Electric Industrial Machines
4.69	Other Fabricated Metal Products
4.40	Computers and Office Machines
4.22	Materials Handling Machinery
4.17	Primary Nonferrous metals Mfg.
4.16	General Industrial Machinery
4.02	Service Industry Machines
3.94	Scientific and Controlling Instruments
3.92	Misc. Electrical Machinery
3.91	Electric Lighting and Wiring
3.91	Farm and Garden Machinery
3.87	Construction and Mining Machinery
3.86	Heating, Plumbing, and fab. metal products
3.76	Screw Machine products, stampings
3.75	Engines and turbines
3.46	Iron and ferroalloy ores mining
3.37	Nonferrous metals ores mining
3.35	Misc. Manufacturing
3.34	Metal Containers
3.31	Ordnance and Accessories
3.31	Household Appliances
3.28	Optical and Photographic Equip.
3.19	Primary Iron and Steel Mfg.
3.06	Stone and Clay mining
2.90	Motor Vehicles and Accessories
2.31	Other furniture and Fixtures
2.28	Rubber and Misc. Plastics
2.11	Household furniture
1.99	Plastics and synthetic materials
1.96	Repair and Maintenance Construction
1.95	Business Services
1.92	Paperboard Containers
1.89	Paints and allied products
1.85	Paper and Paper Products
1.84	Glass and Glass Products
1.81	Wood Containers
1.80	Chemicals and Chemical Products
1.77	Misc. Textile goods
1.77	Drugs
1.72	Lumber and Wood products
1.71	Printing and Publishing
1.68	Footwear and other leather
1.66	Fabrics, yarn and thread
1.63	Stone and Clay products

Table 2.1—continued

Metric	Industry Title
1.62	Auto Repair
1.59	New Construction
1.48	Misc. fabricated textile products
1.47	Coal mining
1.40	Transportation and Warehousing
1.39	Radio and TV Broadcasting
1.29	Health and Educational Services
1.28	Private Electric, Gas, Sanitary Services
1.24	Communications, except radio, TV
1.21	Leather Tanning and Finishing
1.20	Apparel
1.19	Food and Kindred Products
1.18	Chemical and Fertilizer mining
.94	Petroleum refining and related
.89	Eating and Drinking Places
.88	Amusements
.87	Tobacco Manufactures
.87	Livestock and Livestock Products
.85	Forestry and fishery products
.78	Hotels and personal Services
.74	Crude Petroleum and Natural Gas
.73	Agricultural services
.72	Other Agricultural Products
.69	Finance and Insurance
.63	Wholesale and Retail Trade
.34	Real Estate and Rental

The numbers in the first column are the levels of the defense-competing metric. These metric values are proportional to the percentage increase in costs that are expected due to higher defense spending. For example, the "electronic components" industry with a metric value of 6.66 should have had twice the increase in costs due to the increase in defense spending as the "metal containers" industry, which had a metric of 3.34. A metric of zero would indicate no expected wage impact from the increase in defense spending. While there is no clear cutoff between defense-competing and non-defense-competing industries, the range of the defense-competing metric from .3 to 6.6 does indicate that the increase in costs due to defense spending were widely distributed across industries.

However, this metric is only a reflection of expected increases due to defense spending. A wide variety of other influences may have affected prices in these industries, and are not reflected in this metric.

The industries at the top of the list are concentrated in a small number of sectors, including those related to electronics, transportation, and machinery. Many of these industries are popularly thought of as high-tech industries. Electronics and aircraft

industries also appear at the top of the industries identified as high-tech by the U.S. Department of Commerce based on embodied research and development (R&D).[16] Most of the machinery industries fall in an intermediate range based on the Department of Commerce definition.

Another comment on the results is that these are not the same industries that experienced the greatest increases in total demand as a result of the increase in defense spending. Service industries and primary industries were among those that were expected to experience substantially increased demand from defense spending. Table 2.2 lists the industries ranked by the expected increase in total demand. The calculations suggest that these industries do not compete with defense producers for scarce workers to the same extent as the high-tech and machinery industries.

Additional insight into the types of occupations that are most responsible for the increased labor costs of the defense-competing industries is provided in Table 2.3. This is an intermediate result of the calculations, listing the occupations that are likely to have had the greatest wage increases as a result of defense spending. The figures in the left column are changes in the shadow price for occupations.[17] Large changes in shadow prices for occupations are created by a combination of increased demand due to defense purchases, and limited potential supply of those workers among the non-defense employers. Numerous production and engineering occupations appear at the top of the list.

This listing of occupations provides an indication of why the high-technology and machinery industries were among the defense-competing industries. The increase in defense spending generated additional demand for certain specialized skills, and there are a limited number of non-defense industries where these workers are employed.[18] For example, nuclear engineers are at the top of the list in terms of the effects of defense spending. Defense spending is likely to increase the demand for nuclear engineers. An equally important factor is that there is not a large number of nuclear engineers in commercial production. As a result, it is difficult to squeeze those workers out of civilian employment, and wages are likely to increase significantly.

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[16]However, a direct comparison of the listings is not possible since the Commerce list is based on a National Science Foundation Classification System (see L. Davis, 1982). The list also has a substantial overlap with the list of "high-technology" industries as defined by the U.S. Department of Labor based on a high proportion of high-technology workers. See Riche, 1983.

[17]The shadow prices represent the opportunity cost of using each of the labor resources for defense production rather than commercial production.

[18]The fact that the defense-competing industries are overwhelmingly producers of intermediate goods may be related to the assumption of fixed production coefficients. This is further discussed in the final section of the study.

Table 2.2

Total Increases in Demand Due to Defense Spending (1980 to 1983) (increases in current dollars)

Increase in Demand $M	Industry
$13,826	Radio, TV, and Communication equip.
$12,124	Aircraft and Parts
$6,922	Other Transportation Equip.
$5,787	Ordnance and Accessories
$5,101	Electronic Components
$4,328	Business Services
$3,461	Primary Non-Ferrous Metals Mfg.
$3,262	Wholesale and Retail Trade
$3,057	Computers and Office Machines
$2,830	Primary Iron and Steel Mfg.
$2,777	Private Electric, Gas, Sanitary Services
$2,756	Electric Industrial Machines
$2,522	Scientific and Controlling Instruments
$2,351	Transportation and Warehousing
$2,018	Real Estate and Rental
$1,945	Chemicals and Chemical Products
$1,899	Rubber and Misc. Plastics
$1,811	Motor Vehicles and Accessories
$1,661	Metalworking Machinery
$1,650	Crude Petroleum and Natural Gas
$1,632	Petroleum Refining and Related
$1,188	Finance and Insurance
$1,094	Other Fabricated Metal Products
$1,059	Engines and Turbines
$934	Repair and Maintenance Construction
$925	Eating and Drinking Places
$913	Printing and Publishing
$871	Screw Machine Products, Stampings
$859	Misc. Non-Electrical Machinery
$840	Health and Educational Services
$795	Plastics and Synthetic Materials
$779	General Industrial Machinery
$733	Optical and Photographic Equip.
$715	Paper and Paper Products
$699	Heating, Plumbing, and Fab. Metal products
$678	Lumber and Wood Products
$674	Communications, except Radio, TV
$656	Hotels and Personal Services
$504	Materials Handling Machinery
$488	Stone and Clay Products
$401	Food and Kindred Products
$392	Auto Repair
$380	Electric Lighting and Wiring
$353	Fabrics, Yarn and Thread
$346	Coal Mining
$301	Paperboard Containers
$235	Glass and Glass Products
$212	Nonferrous Metals Ores Mining

Table 2.2—continued

Increase in Demand $M	Industry
$181	Construction and Mining Machinery
$172	Radio and TV Broadcasting
$163	Misc. Textile Goods
$151	Paints and Allied Products
$145	Drugs
$144	Misc. Manufacturing
$127	Household Furniture
$12[illegible]	Iron and Ferroalloy Ores Mining
$124	Amusements
$119	Other Agricultural Products
$118	Livestock and Livestock Products
$93	New Construction
$83	Misc. Fabricated Textile Products
$71	Forestry and Fishery Products
$67	Misc. Electrical Machinery
$67	Stone and Clay Mining
$58	Household Appliances
$56	Apparel
$54	Chemical and Fertilizer mining
$54	Other furniture and Fixtures
$53	Metal Containers
$49	Agricultural Services
$41	Farm and Garden Machinery
$18	Wood Containers
$8	Footwear and Other Leather
$4	Leather Tanning and Finishing
$0	Tobacco Manufactures
($228)	Special Industry Machinery
($548)	Service Industry Machines

SENSITIVITY ANALYSIS OF THE RESULTS

The calculation of the defense-competing metric rests on a number of assumptions and on data from a variety of sources. In some cases, there is no alternative to these assumptions and data sources; whatever their shortcomings, they are probably the best that can be done.[19] In other cases, though, there are alternatives, and the implications of using these alternative assumptions and data sources are explored in the calculations. In particular, the sensitivity analysis is focused on the consequences of alternative treatments of labor supply and the elasticity of final demand.

[19]For example, there is no practical alternative to using the input-output tables and labor requirements table. Neither is there any real alternative to accepting the assumptions such as fixed-coefficient production and constant returns to scale that underlie these tables.

Table 2.3

Model Impacts on Occupations

Impact*	Occupational Title
3.95	Nuclear engineers
3.63	Heating equipment setters and set-up operators, metal and plastic
3.49	Soldering and brazing machine operators and setters
3.47	Nonelectric plating machine operators and tenders, setters and set-up operators, metal and plastic
3.28	Mining engineers, including mine safety engineers
3.02	Electric plating machine operators and tenders, setters, and set-up operators, metal and plastic
2.23	Programmers, numerical, tool, and process control
2.02	Electronics repairers, commercial and industrial equipment
1.97	Aircraft engine specialists
1.94	All other printing press setters and set-up operators
1.88	Urban and regional planners
1.55	Aircraft assemblers, precision
1.54	Metallurgists and metal, ceramic, and material engineers
1.51	Electro-mechanical equipment assemblers, precision
1.48	Ship engineers
1.20	Physicists and astronomers
1.19	Industrial engineers, except safety engineers
1.15	Punching machine setters and set-up operators, metal and plastic
1.10	Metal molding machine operators and tenders, setters and set-up operators
1.08	All other physical scientists
1.08	Judges, magistrates, and other judicial workers
1.03	Economists
1.01	Shipfitters
1.00	All other life scientists
.97	All other engineers
.94	Screen printing machine setters and set-up operators
.92	Architects, except landscape and marine
.90	Mechanical engineers
.83	Lathe machine tool setters and set-up operators, metal and plastic
.83	Construction and building inspectors
.83	Operations and systems researchers
.81	Surveyors
.80	Fitters, structural metal, precision
.80	Machine builders and other precision machine assemblers
.80	Management analysts
.78	Civil engineers, including traffic engineers
.77	Biological scientists
.75	Librarians, professional
.75	Electronic semiconductor processors
.74	Teachers, secondary school
.73	Captains and pilots, ship
.72	Drilling machine tool setters and set-up operators, metal and plastic
.72	Grinding machine setters and set-up operators, metal and plastic

Table 2.3—continued

Impact*	Occupational Title
.70	Aircraft mechanics
.68	Counselors
.66	Education administrators
.64	All other precision metal workers
.64	Electrical and electronic technicians/technologists
.63	Mathematicians and all other mathematical scientists
.62	Real estate appraisers
.62	All other electrical and electronic equipment mechanics, installers, and repairers

Comparisons of the Results Using Various Elasticity Sources

The model used in this analysis assumes a fixed supply of skilled workers within certain occupations. Therefore, the extra labor that is required to satisfy the increase in defense demand must be made available by offsetting reductions in non-defense final demand. These reductions in final demand are based on the assumption that certain events occur as a result of defense spending. The increase in spending generates additional demand for labor, some of which is limited in supply, and wages increase for these occupations. Industries that rely on those occupations face an increase in costs, and therefore, prices will increase. However, the price increases will have different impacts depending on the elasticities of demand. In those cases where demand elasticities are low, significant increases in costs are necessary to reduce demand and release workers for defense production. On the other hand, if the elasticity of demand for certain industries' output is high, numerous workers will be released as a result of small wage increases.

In order to incorporate final demand elasticities into these calculations, elasticity estimates were necessary for each of 77 input-output industries. The input-output tables divide final demand into the following four categories:

1) Personal consumption expenditures,
2) Gross private fixed investment,
3) Exports, and
4) Government expenditures.

Estimates of personal consumption elasticities were available from two sources.[20] Although the estimates for certain industries showed substantial variation, the effects of

[20] Mansur and Whalley, 1984; and Petri, 1984.

incorporating alternative demand elasticity sources on the estimates of the defense-competing metric were small. Figure 2.4 is a scatterplot of the defense-competing metric computed with the two different personal consumption elasticities. Each point represents one industry. The strong linear relationship indicates that there is no significant difference between the results. The correlation coefficient is shown in the upper left of the figure.

Demand elasticity estimates for government purchases were not available in the literature, so an additional set of sensitivity tests was performed on a range of plausible elasticity values. In the first case, all government purchases were assumed to be completely inelastic (an elasticity of zero). The second set of results is based on unitary government purchase elasticities (elasticities of negative one). These first two estimates of government purchase elasticities were chosen because they represent plausible upper and lower bounds of elasticity estimates. In the first case, the government has a set of requirements but no budget constraint, and in the second case, the government purchases are bound by a rigid budget constraint. The final set of results was based on a combination of zero and unit elasticities, for example with defense purchases and medical care with zero elasticities (determined by requirements), and local government expenditures with unit elasticities (budget constrained).

The plot matrix in Fig. 2.5 illustrates the impact of these alternative estimates of government purchase elasticities on the results of the defense-competing metric. The

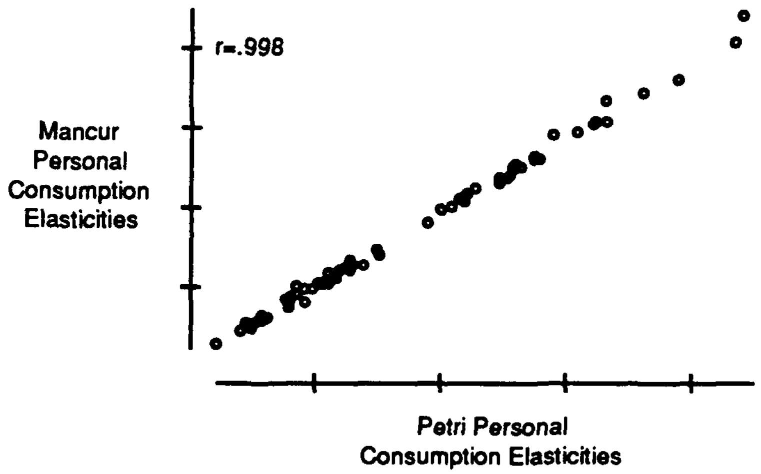

Fig. 2.4—Scatterplot Across Personal Consumption Elasticities

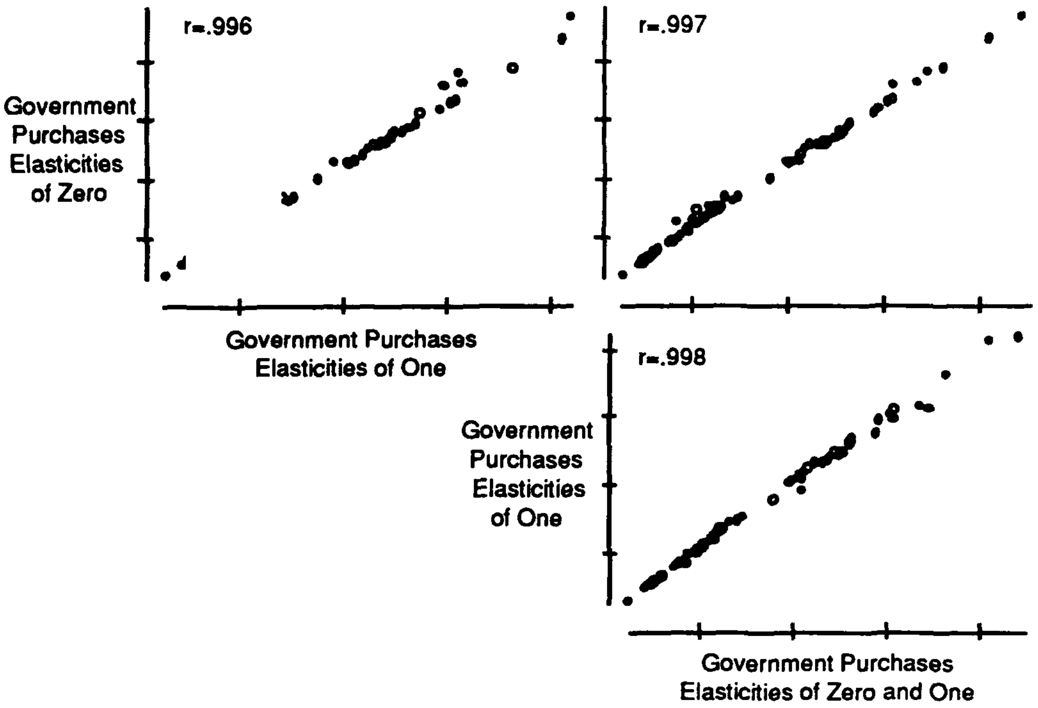

Fig. 2.5—Scatterplot Across Government Purchases Elasticities

scatterplots indicate that the metric results are insensitive to assumptions about the elasticity of demand for government purchases. For example, the upper left plot indicates that there is virtually no difference in the industry values of the defense-competing metric when calculated with government demand elasticities of negative one compared with government demand elasticities of zero. These comparisons demonstrate that the various final demand elasticities that are incorporated into the calculations do not have a large impact on the values of the defense-competing metric.

Comparisons of the All-Occupations and Supply-Constrained Occupations Results

Another assumption of this model is that growth in some parts of the labor force is severely limited in the short run. This assumption is embodied in the model as supply elasticities of zero for certain labor occupations. The occupations characterized by inelastic supply were identified using the *Occupational Outlook Handbook*,[21] which describes the

[21] U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2250, April 1986.

qualifications necessary for most of the occupations included in the research.[22] The *Handbook* has detailed descriptions of most of the occupations used in the calculations, and each of these descriptions includes a section on "Training, Other Qualifications, and Advancement." To determine which occupations might be realistically described as having a zero elasticity in the short run, three specific criteria were used to identify those jobs that might have a low elasticity. Occupations were selected that mentioned a specific educational, experience, or licensing requirement that might be expected to limit entry into the occupation.

Because of the lack of specific information about certain occupations, and the lack of precision in the criteria, there is substantial uncertainty introduced by this choice of occupations. As an alternative, results were calculated under the assumption that all the occupations were supply-constrained. Fig. 2.6 indicates that there is a relatively strong positive relationship between the defense-competing metric results calculated based on the assumption that all occupations are supply constrained and the metric results calculated with only certain occupations assumed to be supply-constrained. The plots show significant differences for some industries. Points that lie below the point cloud indicate industries that have a significantly higher value of the defense-competing metric using all occupations.

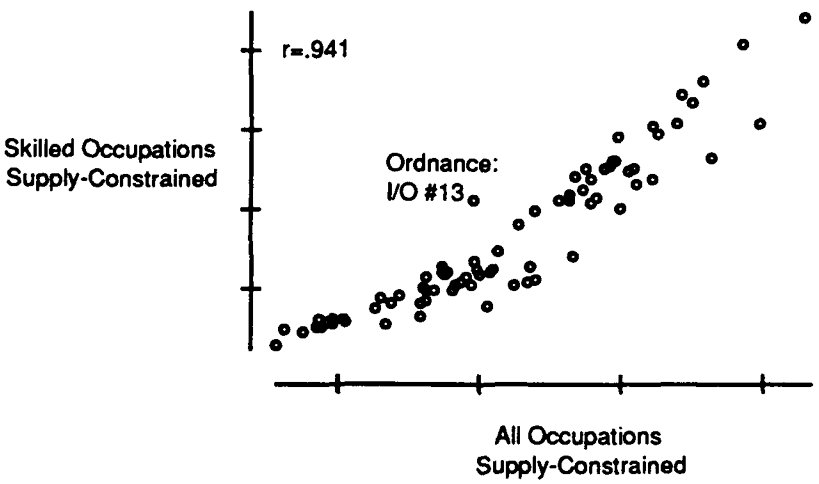

Fig. 2.6—Scatterplot Across Labor Supply Assumption

[22]Appendix B describes the selection criteria and provides a listing of the supply-constrained occupations.

These would include industries that employ significant numbers of workers in occupations affected by defense spending, but that are not considered supply-constrained. Points that lie above the point cloud indicate industries that have a higher defense-competing metric based on calculations using only occupations that are considered supply-constrained.

One particular outlier above the center of the point cloud is visible in Fig. 2.6: Ordnance and accessories (I-O category 13). This industry appears to rely heavily on occupations which were identified as supply-constrained, and therefore has a relatively higher metric using the subset of occupations.

Comparisons Using Regression Analysis

The rank-order correlation between the defense-competing metric computed with all occupations assumed to be supply-constrained and the metric with only skilled occupations assumed to be supply-constrained was significantly higher than the linear correlation, suggesting a non-linear relationship between the variables. The plot also appears to suggest a curvilinear relationship. The all-occupations metric (all occs.) was regressed on the supply-constrained occupations metric (s-c-occs). As indicated by the regression results reported in Table 2.4, the all-occupations metric is an excellent predictor of supply-constrained metric, with a highly significant t-ratio of over twenty.

Fig. 2.7 is a residual plot for the regression analysis. As expected from the original graphs, the residual shows some evidence of a curvilinear relationship.

To capture this curvilinear relationship, a squared term (sq_all occs.) is incorporated into the following regression (Table 2.5). The squared term is also highly significant, with a

Table 2.4

Regression of All-Occupations Metric and Supply-Constrained Occupations Metric

Dependent variable is: S-C-OCCS
R2 = 88.6T R2(adjusted) = 88.5%
s = 0.4976 with 77 – 2 = 75 degrees of freedom

Source	Sum of Squares	df	Mean square	F-ratio
Regression	144.623	1	145	584
Residual	18.5667	75	0.247557	

Variable	Coefficient	s.e. of Coeff	t-ratio
Constant	–1.00358	0.1541	–6.51
all occs.	0.627106	0.0259	24.2

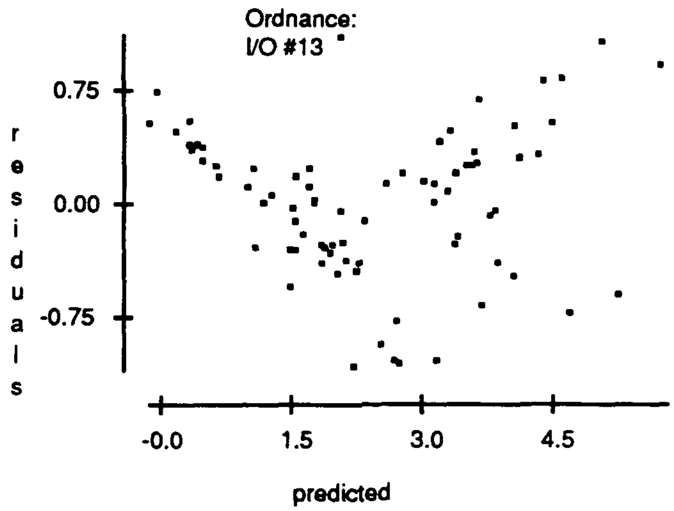

Fig. 2.7—Scatterplot of Residuals

Table 2.5

Second Order Regression Results

Dependent variable is: S-C-OCCS
$R2 = 91.4\%$ R2(adjusted) = 91.2%
s = 0.4359 with 77 – 3 = 74 degrees of freedom

Source	Sum of Squares	df	Mean square	F-ratio
Regression	149.128	2	74.6	392
Residual	14.0615	74	0.190020	

Variable	Coefficient	s.e. of Coeff	t-ratio
Constant	0.218830	0.2851	0.768
all occs.	0.120807	0.1064	1.14
sq_all occs.	0.044612	0.0092	4.87

t-ratio of over 4. The residual plot for the second order regression (Fig. 2.8) indicates no obvious patterns, although some heteroscedasticity appears to be present.[23]

The success of the second order regression provides evidence of a curvilinear relationship between the two metrics. This curvilinear relationship results because both metrics have low values for the same industries, the all-occupations metric has higher values

[23]This appears in Figure 2.8 as the increasingly vertical spread of points in moving from the left to the right side of the plot.

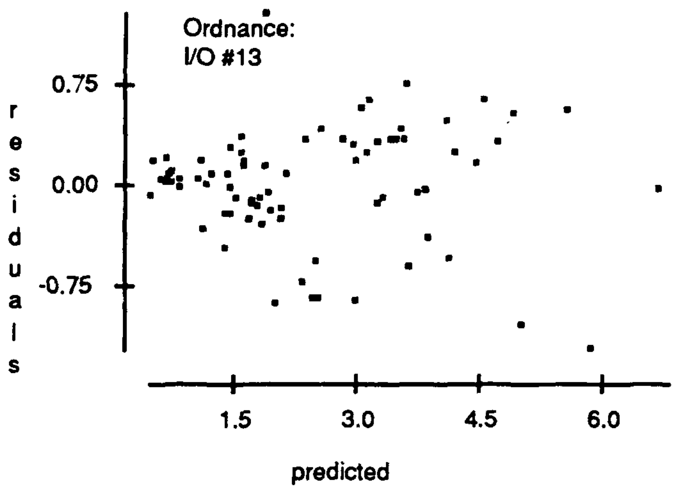

Fig. 2.8—Second Order Residuals

for the intermediate industries, and both metrics have the same highly impacted industries. Since the purpose of the metric is to identify the greatest number of industries most affected by defense spending, the supply-constrained metric may offer a better way of distinguishing between the highly impacted and the less impacted industries.

3. MEASURING TRADE PERFORMANCE

GENERAL CONSIDERATIONS

The aim in this section is to develop a metric that will highlight the differential performance of sectors that are exposed to competition for scarce inputs. An ideal metric would screen out the influence of factors that affect the trade performance of all sectors (exchange rate changes, for example) leaving the influence of sector-specific factors. The defense-competing metric developed in the previous section reflects the percentage increase in input costs and output prices that is expected to result from higher wages for skilled workers. Therefore, the trade performance measure should be designed to be sensitive to the changes in trade that would result from a percentage increase in the prices of U.S. products.[1]

A defense-competing industry will face higher costs as a consequence of increased defense spending and would be expected to raise its prices. This should lead to a decrease in the quantity of goods exported, although the amount of the decrease depends on the elasticity of export demand. An increase in costs will also affect imports even though the price of imports is not directly affected. The price of imports relative to domestically produced products has decreased, and therefore, the quantity of imports would be expected to increase. The increase in quantity will depend on the elasticity of demand for imports. Therefore, in industries with a high defense-competing metric, a decrease in the quantity of exports and an increase in the quantity of imports is expected.[2] Of course, the trade performance of individual industries is affected by a large number of other factors which may have nothing to do with the increase in defense spending. These influences would show up as noise in the measurement of trade performance.

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[1]The trade data used for this analysis are official U.S. trade statistics produced by the U.S. Department of Commerce, Bureau of the Census. The publications used were *E.A. 675: U.S. Exports, SIC Division by SIC-based 2-Digit, 3-Digit and 4-Digit Product Codes*, and *I.A. 275: U.S. Imports for Consumption and General Imports, SIC Division by SIC-based 2-Digit, 3-Digit and 4-Digit Product Codes*, for 1980 through 1987. SIC trade statistics were used because they allow easy comparison of imports and exports, and because concordances between the Input/Output and SIC industry classification systems are available. Comparisons were made at the 3-Digit SIC level based on nominal dollar values for the calendar years 1980 through 1987.

[2]Data available do not allow the direct observation of a change in quantity. Even at the most disaggregated level, trade categories include a changing mix of products, rendering the quantity measures unreliable. For this reason, we have used the trade statistics reported in terms of current dollar value, representing Price*Quantity (Revenue). In order for an export price increase to lead to a decrease in export revenue, the elasticity must be less than -1. The estimates of demand elasticities for exports indicate that this assumption is not unrealistic. See Appendix A for sources of elasticity estimates.

An appropriate trade performance measure would combine the import and export performance into a single number that could be compared with the defense-competing metric. Unfortunately, there are a number of characteristics of trade flows that make this measurement more difficult. In particular, three characteristics of exports and imports during this period have to be considered in the development of the trade metric:

- industries vary greatly in size, both in a comparison of imports and exports, and in comparison to other industries;
- imports in virtually all categories grew much more rapidly during the period than exports; and
- certain industries could be characterized as "growth" industries where both imports and exports grew more rapidly than the all-export and all-import averages, while "mature" industries grew more slowly or declined in terms of both exports and imports.

Each of these characteristics has implications for the trade metric.

Because the volume of trade varies widely across industries, the absolute growth in surplus or deficit for a particular industry may not be a good measure of trade performance. For example, an increase in the trade deficit for a particular industry could occur despite a much larger growth rate of exports if the volume of imports was substantially larger in the base period. Trade measures based on rates of change rather than absolute growth control for the size of the industry in the base period, and also control for the potential imbalance of imports and exports within an industry.

A second difficulty in measuring U.S. trade performance is that imports as a group performed much better than exports during the period from 1980 through 1987. For example, only six of 71 three-digit SIC industries had a higher export growth rate than import growth rate from 1980 through 1987. The poor overall performance of exports in comparison with imports has been attributed to the high value of the dollar, high gross domestic product (GDP) growth rates in the United States in comparison with other countries, and other factors. However, the purpose of this research is to determine whether the poor performance of particular industries in international trade was related to defense spending. Since all industries performed relatively poorly, a simple comparison of imports and exports is uninformative.

A more useful measure of industry trade performance would control for the overall rate of import and export growth. The measure developed for this research compares the

individual industry's export performance to the all-export average, and compares the individual industry's import performance to the all-import average. Operationally, only trade from the 71 SIC 3 categories (manufactures) is included in the all-import and all-export averages. The prices of non-manufactures—particularly oil and agricultural products—fluctuated wildly over the period and would introduce distortions into the measurement. Also, the trade performance of manufactures can be more directly linked to the impact of the defense-competing metric using the current data sources than the performance of non-manufactures.[3]

Individual export or import performance measures—even if based on the difference between the individual industry and the all-export or import average—are not sufficient. In industrial sectors where trade is expanding rapidly (computers or electronic components may be examples), both imports and exports are increasing. Whether or not trade performance in these sectors is "good" will depend on the growth of imports and exports of those industries relative to the all-import or all-export averages.

SPECIFIC CRITERIA

These general considerations for the trade metric can be incorporated into more formal criteria to evaluate potential trade performance metrics. In particular, three specific patterns of change in trade flows, and how each should be reflected in a reasonable metric of trade performance are considered. None of these three cases is likely to have occurred. However, a metric that fails to produce a sensible result in any of these three cases cannot be considered a reasonable metric and should be dismissed from further consideration. A final criteria is related to the balance of the import and export contribution to the trade metric.

In the remainder of this study, X_i and M_i will denote the values (in nominal terms) of exports and imports of commodity i, respectively. X and M will denote the values of total exports and total imports—the sums, respectively, of all the X_is and M_is. Δ denotes a change in a quantity. ΔX_i, therefore is the change in the value of exports of commodity i.

[3]An additional reason only SIC 3 manufactures were used in the calculations is related to the concordance between the I-O and SIC concordance. In most of the manufacturing industries, this concordance was relatively straightforward. However, in many agricultural and service industries, there were a number of "many-to-many" concordances which prevent the transfer of data from one classification system to another. Using only manufacturing industries alleviated this problem. The concordance is provided in Appendix D.

Insensitivity to Relative Price Changes

Detailed statistics of U.S. trade are compiled only in nominal terms. Therefore, the metric must make allowance for the fact that even if nothing real changes, the value of imports or exports may change as a consequence of price changes.

Consider the case where there is no change in real trade flows. The volumes of all imports and exports remain exactly the same. Suppose that the prices of all commodities, with one exception, rise by p percent. The one exception is commodity i. The price of this commodity rises by p_i percent. In this case, there will certainly be changes in the values of imports and exports of commodity i; each will have risen by p_i percent. Since nothing real has changed, however, it hardly makes sense to characterize the trade performance of the sector producing commodity i as either good or bad. In this case, the trade performance metric should reflect neutral trade performance.[4]

Insensitivity to Uniform Growth in Imports or Exports

Some factors will affect the performance of all imports or of all exports. More rapid income growth in the United States, for example, will bring increases in imports of most commodities. A rise in the value of the dollar relative to other currencies will typically weaken the performance of all exports and make all imports appear more attractive. Certainly, U.S. trade flows were strongly influenced by such factors during the early 1980s. The overall research aim is to test whether the industries competing most directly with defense contractors for scarce inputs showed worse trade performance than did industries that did not face such competition. To do this, the metric should abstract from underlying circumstances that may have affected the trade performance of all industries and that had nothing to do with the defense buildup. Another way of saying this is that the interest is in how increased defense spending may have affected the *relative performance* of U.S. industries in international trade, as opposed to the overall *volume* of imports or exports.

Ideally, all trade flows would be adjusted for income and exchange rate effects. To do so, of course, would require estimates of income and price elasticities for all categories of imports and exports. Unfortunately, the necessary elasticity estimates are not available for the detailed trade categories used for the analysis. The next best course may be to assume that these elasticities are equal across all categories of imports and across all categories of exports (although not necessarily the same for imports and for exports). Thus, a change in

[4]This criterion precludes the use of measures that are based on the absolute values (surpluses or deficits) of the exports and imports. For example, if imports of an industry were twice as large in absolute value terms as exports, a price rise of p percent for all products would result in what appeared to be a good performance for imports despite the fact that there was no real change in trade flows.

income or a change in exchange rates will affect the value of all imports equally and the value of all exports equally.[5]

Consider the case where imports of all commodities grow by the same amount. Presumably, this uniform growth is due to some economy-wide phenomenon. No sector-specific factors have influenced trade flows. No one sector has experienced trade performance that is better or worse than any other sector. Consequently, the trade performance metric for any particular sector should show a neutral result.

Insensitivity to Product Classification

The classification of products into categories for the purposes of reporting trade statistics is necessarily arbitrary. Any trade category could be split into smaller categories. The value of the trade performance metric should not be affected by arbitrary changes in the classification of products.

Consider the following case. Imagine a perfectly homogeneous category of traded products. All products in this category are identical. Now suppose that a statistical clerk decides to divide this category of products into two categories: the first including all imported or exported items with even serial numbers and the second made up of all items with odd serial numbers. Presumably serial numbers are irrelevant to import or export demand, and the trade performance metric should show that the trade performance of each of the two new categories is identical to the trade performance of the original combined category.

Another way of saying this is that the trade performance metric is insensitive to the scale of imports or exports. The value of the metric should not be influenced by the magnitude of trade flows. If the value of imports and exports in a category is changed by the simple redefinition of the category, the value of the metric should not change.

Formally, if the values of the trade performance metric for categories i and j are equal, then the value of the metric for the category combining i and j must be equal to the value of either of the original categories independently.

Equal Sensitivity to Exports and Imports

A final consideration in the selection of a metric is that changes in imports and changes in exports have relatively equal weight in the overall metric. This is necessary since it is the performance of export industries relative to the performance of import industries

[5]Although this assumption that all elasticities are equal is not realistic, it will not bias our analysis unless the differences are systematically related to the defense-competing metric.

that is of interest. If the trade measure is largely determined by either exports or imports, growth industries will appear at the top of the list, and declining industries will appear at the bottom of the list. On the other hand, an equally weighted measure would identify industries where imports were growing and exports were declining, or vice versa.

A TRADE PERFORMANCE MEASURE

The requirements for a reasonable trade performance metric described in the preceding section may not appear to be particularly stringent but there does not appear to be any single metric that meets all four of these requirements exactly. However, there is a metric that meets these requirements (at least approximately) under plausible conditions. The metric and the circumstances in which it satisfies the conditions outlined are described in this section. As above, X_i and M_i denote the values (in nominal terms) of exports and imports of commodity i, respectively. X and M denote the values of total exports and total imports—the sums, respectively, of all the X_is and M_is. Δ denotes a change in a quantity. ΔX_i, therefore is the change in the value of exports of commodity i. In all three metrics, a positive value of the metric indicates a "good" trade performance, and a negative value indicates a "poor" trade performance.

The metric is based on the relative ranks of export and import trade performance, and is calculated as:

$$\text{Metric}_i = \text{rank}\,\frac{DX_i}{X_i} - \text{rank}\,\frac{DM_i}{M_i}\ .$$

A rank of 1 indicates the slowest growing and n the fastest growing export or import industry. For example, the computer industry ranked 70 out of 71 industries (the second fastest growing) in terms of exports, and ranked 71 out of 71 (the fastest growing), in terms of imports, so $\text{Metric}_{\text{computers}} = 70 - 71 = -1$. This metric indicates that imports of computers performed slightly better than exports over this period.

The meaning of the rank metric can be displayed graphically, since the greater the positive or negative slope of the line, the better or worse the trade performance (Fig. 3.1). The computer industry was at or near the top of both the import and export rankings, and therefore, the metric for the computer industry is near zero. In contrast, the steep downward slope of the line connecting the import rank with the export rank of iron and steel indicates that imports performed significantly better than exports in that industry. The metric of –63 reflects the differential performance of imports and exports. Similarly, exports of

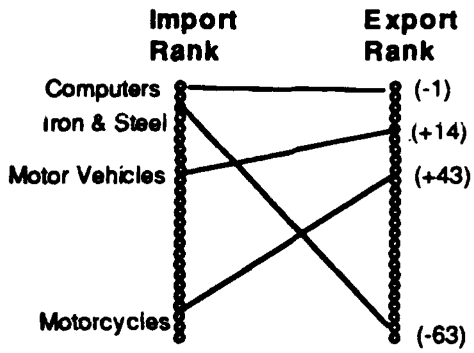

Fig. 3.1—Trade Metric Illustration

motorcycles performed significantly better than imports, and the metric reflects that performance.

Insensitivity to Relative Price Change

Suppose that there are no changes in the volumes of trade flows of any commodity. Suppose that the price of commodity i, both imports and exports, rises by p_i and that the prices of all other commodities rise by p percent. Since there has been no change in real trade flows, the metric should show a neutral result. In the case of the trade metric, the value is Rank X_i – Rank M_i = 0 whether p_i is greater than or less than p. Therefore, the metric meets the first requirement.

Insensitivity to Uniform Growth in Imports or Exports

Suppose that the value of exports in every category grows by x percent and that the value of imports in every category grows by y percent. Since each export industry performed exactly as well as the all-export average, the metrics should produce a neutral value of 0 for any sector i. In the case of the trade metric,

$$\text{Metric}_i = \frac{n+1}{2} - \frac{n+1}{2} = 0$$

Therefore, the metric meets the second criterion even if x and y are different.

Insensitivity to Product Classification

Imagine that a homogeneous category of products is divided into two new categories. Call these new categories category i and category j. Since the products in the new categories are identical to each other, the original metric for the categories including both types of products should be equal to each of the new products accounting for half of the original

category. In the case of the trade metric, $Metric_{i+j}$ = $Metric_i$ and the metric appears to meet the criteria. However, the larger number of industries may alter the metrics of other industries since all industries above the divided industry will have a greater rank.

Equal Sensitivity to Exports and Imports

A number of potential metrics were developed that were based on the ratio of the industry growth to the overall import or export growth rate. However, this method did not result in equally balanced import and export contributions to the overall trade metric. Due to the more rapid growth of imports during the period, the denominators of the import components are substantially larger than the denominators of the export components. In fact, the average export growth for the years 1984 and 1985 was so small that the individual industry metrics "blew up" since it was the ratio of some positive number to a near zero denominator. Since the resulting export fractions were so much larger than the import fractions, they had a dominant influence on the overall trade metric.

Contributions of the export and import components to rank-order trade metric are roughly equal. The correlation between the import and the export component is .621, and the correlation between the metric and the import component of is –.598. As a result, the metric is more sensitive to changes in both import and export performance.

COMPARISONS BETWEEN YEARS

It is useful to examine the results of trade performance measure over the years of interest for the analysis. The period from 1980 to 1983 was chosen as the most likely to produce cost increases in defense-competing industries. However, the cost increases might not have an immediate impact on trade performance. The impacts of the increases in defense spending might occur immediately after the defense buildup or with a lag of a few years. Therefore, the effects of defense spending should be compared to the trade performance for a series of years to capture any possible lagged effects. In this study, a one to four year lag was included in the analysis.

This raises the question of how the trade performance measure differs over the periods of interest. If the trade performance measure differs greatly from one year to the next, this would suggest that year to year fluctuations rather than long-term trends play a large role in the trade performance measure. Figure 3.2 is a plot matrix of the trade metric from the pre-defense-buildup year of 1980 through the years 1984, 1985, 1986, and 1987. The correlations are shown in the upper left corner of each plot.

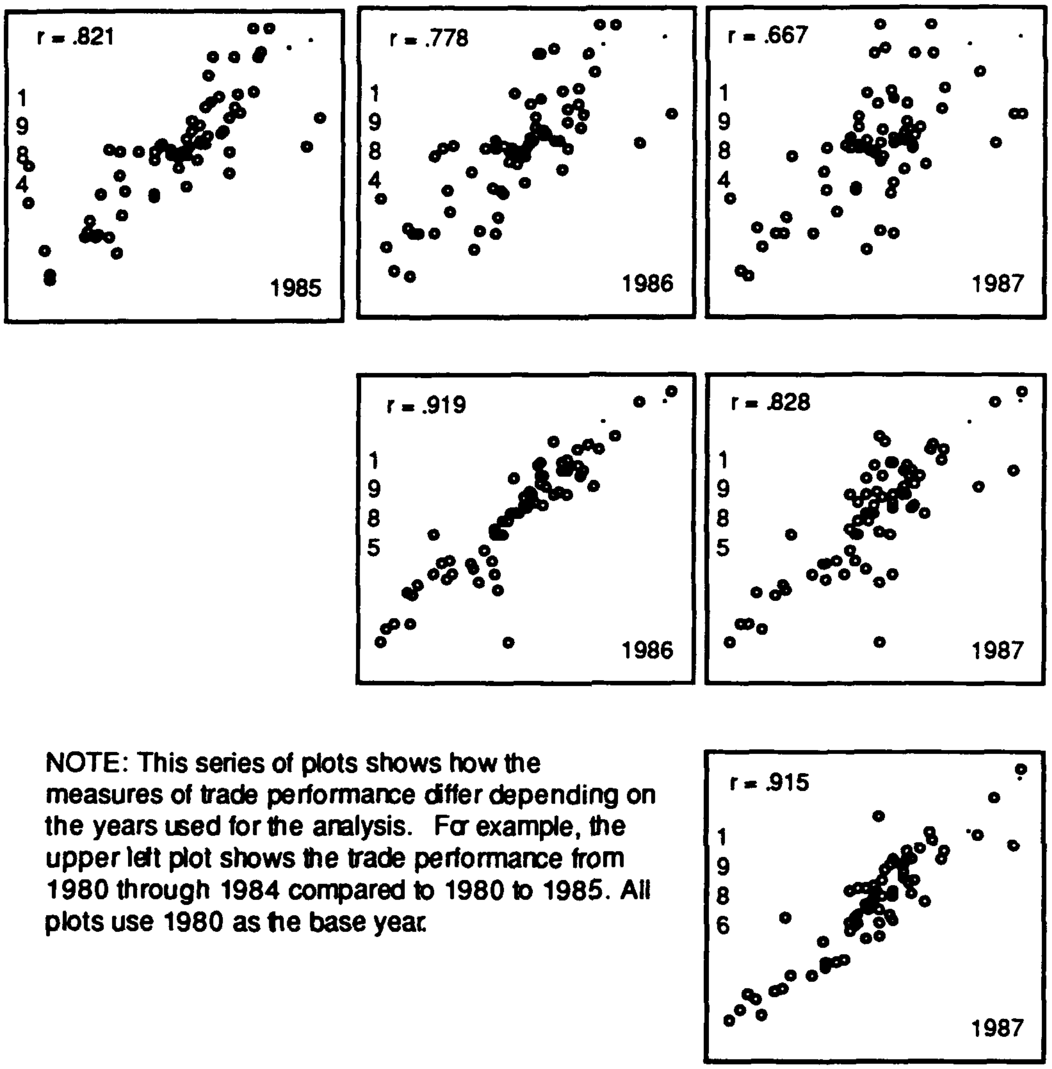

Fig. 3.2—Plot Matrix of the Trade Metric for Years 1984–1987

Not surprisingly, the differences between trade performance measures for consecutive years (as shown by the first plot in each row) are relatively small, but increase over time. This is especially apparent in the near linear relationships for the plots comparing the values for 1985/1986, and 1986/1987. It is also evident that the differences between the years 1984 and 1985 are greater than the differences between other consecutive years. As a result, testsof association using the trade performance measures from 1980 through 1984 may produce significantly different results than the results for 1980 through 1985, 1986, or 1987.

TRADE METRIC VALUES

The following tables report values for the three trade performance metrics. Each table shows the thirteen manufacturing industries with the "best" trade performance for the given years and the thirteen industries with the "worst" trade performance. As is suggested by the correlations between the trade performance of the different years, the lists of industries are similar from year to year. For example, industries such as "missiles and space" and "aircraft and parts" were among the "best" performers in each of those years. On the other hand, "iron and steel," "yachts," and "service industry machines" were among the worst performers in each of the four years shown.

Table 3.1

1980 to 1984 Best and Worst Performers

	Best Performance		Worst Performance
SIC	Industry	SIC	Industry
374	Railroad Equipment	373	Yachts and Pleasure Boats
346	Metal Forgings and Stampings	316	Leather Luggage
359	Non-Electrical Machine Parts	335	Rolled or other Non-Ferrous Metal
376	Missiles and Space Vehicles[1]	393	Musical Instruments
315	Leather Gloves	391	Jewelry and Silverware
319	Misc. Leather Goods	327	Concrete, Gypsum, & Plaster Products
326	Ceramic Products or China	358	Refrigerators & Service Ind. Machines
348	Ordnance and Accessories	395	Pens, Pencils, & Artist's Materials
375	Motorcycles and Bicycles	365	Radio and TV Equipment
372	Aircraft and Parts	353	Construction & Oil Field Machinery
384	Surgical & Medical Instruments	341	Drums, Cans or Boxes of Metal
351	Engines and Turbines	363	Household Appliances
345	Fasteners of Metal	332	Iron and Steel Products

[1]Due to the small volume of imports in this of these products, there is no import category corresponding to Missiles and Space. Therefore, the trade performance of this industry for all of the years in the analysis is simply a comparison of the industry exports to the all industry average.

Table 3.2

1980 to 1985 Best and Worst Performers

SIC	Best Performance: Industry	SIC	Worst Performance: Industry
306	Plastic or Rubber Medical Supplies	303	Reclaimed Rubber
359	Non-Electrical Machine Parts	332	Iron and Steel Products
399	Misc. Manufactured Products[1]	393	Musical Instruments
376	Missiles and Space Vehicles	316	Leather Luggage
374	Railroad Equipment	373	Yachts and Pleasure Boats
315	Leather Gloves	358	Refrigerators & Service Ind. Machines
326	Ceramic Products or China	353	Construction & Oil Field Machinery
346	Metal Forgings and Stampings	341	Drums, Cans or Boxes of Metal
372	Aircraft and Parts	395	Pens, Pencils, & Artist's Materials
343	Heating Equipment	365	Radio and TV Equipment
384	Surgical & Medical Instruments	321	Flat Glass
348	Ordnance and Accessories	344	Fabricated Structural Metal Products
345	Fasteners of Metal	327	Concrete, Gypsum, & Plaster Products

[1] Three factors may be responsible for the growth of this residual category. Export documentation for certain U.S. shipments to Canada are often poorly prepared, and the products which cannot be classified are placed in this category. In addition, the concordance between the export classification system and the SIC classification system may not be complete for certain types of products, which may also result in products being assigned to this SIC which belong in other groups. Finally, new products may not be easily placed in an existing SIC category. These may also be areas of rapid growth.

Table 3.3

1980 to 1986 Best and Worst Performers

SIC	Best Performance: Industry	SIC	Worst Performance: Industry
306	Plastic or Rubber Medical Supplies	332	Iron and Steel Products
359	Non-Electrical Machine Parts	393	Musical Instruments
399	Misc. Manufactured Products	316	Leather Luggage
374	Railroad Equipment	353	Construction & Oil Field Machinery
376	Missiles and Space Vehicles	373	Yachts and Pleasure Boats
346	Metal Forgings and Stampings	358	Refrigerators & Service Ind. Machines
375	Motorcycles and Bicycles	395	Pens, Pencils, & Artist's Materials
326	Ceramic Products or China	324	Cement
383	Optical Instruments	327	Concrete, Gypsum, & Plaster Products
311	Tanned and Finished Leathers	328	Cut Stone or Stone Products
372	AircraftY and Parts	321	Flat Glass
345	Fasteners of Metal	363	Household Appliances
343	Heating Equipment	344	Fabricated Structural Metal Products

Table 3.4

1980 to 1987 Best and Worst Performers

Best Performance		Worst Performance	
SIC	Industry	SIC	Industry
306	Plastic or Rubber Medical Supplies	332	Iron and Steel Products
359	Non-Electrical Machine Parts	316	Leather Luggage
383	Optical Instruments	373	Yachts and Pleasure Boats
399	Misc. Manufactured Products	353	Construction & Oil Field Machinery
375	Motorcycles and Bicycles	393	Musical Instruments
376	Missiles and Space Vehicles	358	Refrigerators & Service Ind. Machines
372	Aircraft and Parts	395	Pens, Pencils, & Artist's Materials
343	Heating Equipment	341	Drums, Cans or Boxes of Metal
326	Ceramic Products or China	324	Cement
346	Metal Forgings and Stampings	327	Concrete, Gypsum, & Plaster Products
301	Tires and Tubes	362	Electrical Industrial Apparatus
311	Tanned and Finished Leathers	321	Flat Glass
313	Leather, Cut to Shape	328	Cut Stone or Stone Products

4. TESTS OF ASSOCIATION

THE ASSOCIATION BETWEEN DEFENSE SPENDING AND TRADE PERFORMANCE

The question addressed in this research is whether the sharp increase in defense spending had a negative impact on the trade performance of defense-competing industries. A finding confirming such an effect would be a negative relationship between the trade performance and defense-competing measures. Forty-eight different combinations of trade and defense-competing metrics were tested to determine whether there is any association between defense spending and trade performance. Different trade metrics and different yearly combinations are incorporated into the analysis to test the sensitivity of the results to different trade metrics and to different lags in the effect of defense spending.[1] In addition, there are a number of versions of the defense-competing metric, based on different assumptions about the elasticity of final demand for products and assumptions about the elasticity of supply for labor.[2]

Fig. 4.1 displays the scatterplot and the regression line for one combination of trade performance and defense-competing measures. The results are typical in that the scatterplot and the statistical analysis show no evidence of a negative relationship between the two measures. The slope of the regression line is 1.05, with a t-statistic of .327, indicating that there is no statistical evidence for either a positive or negative relationship between the two measures.[3] In addition, the point cloud does not appear to have any non-linear relationships that might be further explored.[4]

Other combinations of trade performance and defense-competing metrics show similar results. The regression results are provided in the following tables, where 12 regression results for each trade performance metric are included in each table. Tables 4.1, 4.2, 4.3 and 4.4 summarize the trade performance of industries from 1980 through 1984, 1985, 1986 and 1987. The first two columns of data in each table present the results for calculations based on the assumption that all occupations have inelastic supply over the period, and the third

[1]The "defense-competing" metric was regressed against the trade metric results for 1980 through 1984, 1985, 1986 and 1987.

[2]Each trade performance metric is compared with twelve different defense-competing metrics.

[3]The regression cannot be used in the form $\Delta P/P = \beta(\Delta Q/Q)$ since reliable quantity trade statistics are not available. Using the revenue data available, we estimate $\Delta P/P = \gamma(\Delta PQ/PQ) = \gamma(P\Delta Q+Q\Delta P)/PQ = \gamma(\Delta Q/Q+\Delta P/P)$. $(1-\gamma)(\Delta P/P) = \gamma(\Delta Q/Q)$, and $(\Delta P/P) = (\gamma/((1-\gamma))(\Delta Q/Q)$.

[4]This combination of defense-competing and trade metrics is the defense-competing metric based on skilled occupations, Mancur personal consumption elasticities, and unit government purchase elasticities and the trade metric based on changes in trade from 1980 through 1984.

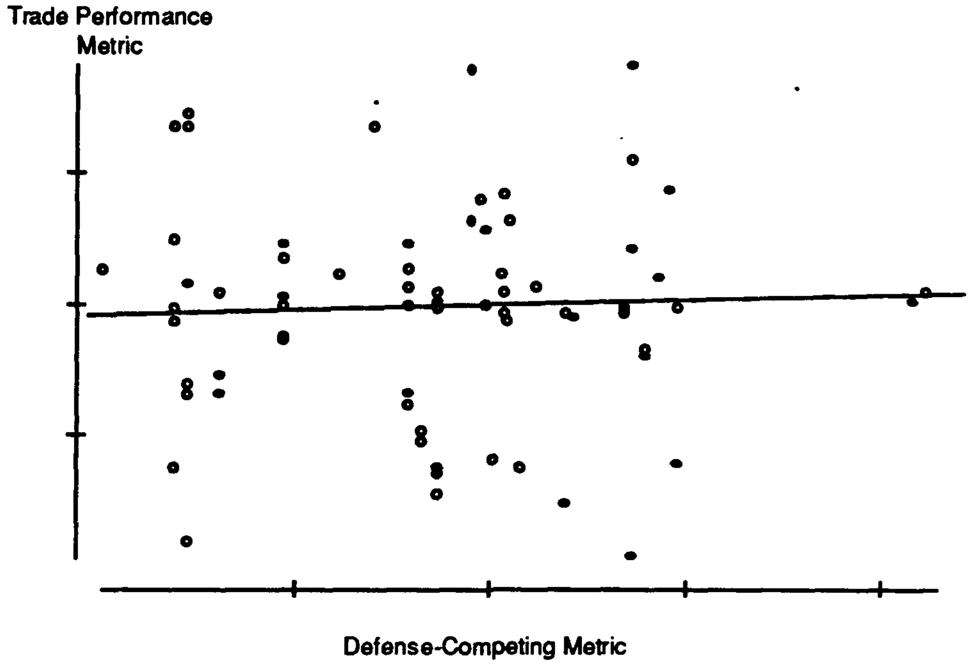

Fig. 4.1—Scatterplot of Trade and Defense-Competing Metrics

and fourth columns of data present the results for calculations where only a subset of supply-constrained occupations are used. Each of the rows indicated in the left-hand column refers to a particular set of final demand elasticities. There are six combinations of final demand elasticities, based on two different personal consumption elasticities (mpc and ppc), and three different government purchase elasticities (g.0, g.1, and g.m).[5]

The first observation is that there are no statistically significant results. The coefficients for the regression are both positive and negative, and most of the t-statistics are small.[6] Differences between the regression results using the trade metrics over a period of years are also relatively small.

One assumption which does produce systematic changes in the results is the assumption about the elasticity of labor. In the regressions where all occupations are assumed to have a zero elasticity (first two data columns), the coefficients of the regression are typically negative, although insignificant. When the regressions are calculated with only

[5]See Appendix B for a description of these sources.

[6]In fact, it is somewhat surprising that none of the results are significant since so many different (although not independent) combinations of measures were attempted.

Table 4.1

Regression Results, 1980–1984

Elasticity Combination	All Occupations		Skilled Occupations	
mpc/g.0	R^2 (%)	0	R^2 (%)	.3
	Coeff.	–.27	Coeff.	1.2
	t-stat	–.15	t-stat	.5
ppc/g.0	R^2 (%)	0	R^2 (%)	.5
	Coeff.	.04	Coeff.	1.4
	t-stat	.02	t-stat	.63
mpc/g.1	R^2 (%)	.3	R^2 (%)	.1
	Coeff.	–1.17	Coeff.	1.05
	t-stat	–.47	t-stat	.33
ppc/g.1	R^2 (%)	.2	R^2 (%)	.2
	Coeff.	–.88	Coeff.	1.18
	t-stat	–.38	t-stat	.39
mpc/g.m	R^2 (%)	0	R^2 (%)	.3
	Coeff.	–.25	Coeff.	1.31
	t-stat	–.13	t-stat	.52
ppc/g.m	R^2 (%)	0	R^2 (%)	.5
	Coeff.	–.49	Coeff.	1.43
	t-stat	–.03	t-stat	.60

NOTE: This table displays the results for the regressions with the trade performance metric from 1980 to 1984 as the dependent variable and 12 different versions of the defense-competing metric as the independent variable. The first two columns of results reflect the defense-competing metric assuming all occupations are supply-constrained for the six combinations of final demand elasticity figures listed on the left-hand side. The last two columns show the same results using only a subset of occupations that are assumed to be supply-constrained.

the occupations assumed to be supply constrained (third and fourth data columns), the coefficients are typically positive, although still insignificant.

RETRACING THE ANALYSIS

These tables provide no evidence that defense spending had a negative effect on the trade performance of industries. This suggests that whatever effects defense spending may have had were too small to observe among all the other changes in the U.S. economy during the mid-1980s. It is also possible, however, that certain data or assumptions may have led to this finding. As a result, it is useful to examine more closely the methods used to test this theory of how defense spending might affect trade, and indicate the ways in which noise or bias might have affected the analysis. This examination may also suggest other influences that could lead to the observed results.

Figures 4.2 through 4.5 illustrate the steps involved in the development of the hypothesis. Each of the shaded rectangles indicates a type of data or intermediate result.

Table 4.2

Regression Results, 1980–1985

Elasticity Combination	All Occupations		Skilled Occupations	
mpc/g.0	R^2 (%)	0	R^2 (%)	1.7
	Coeff.	–.02	Coeff.	2.8
	t-stat	–.00	t-stat	1.1
ppc/g.0	R^2 (%)	0	R^2 (%)	1.8
	Coeff.	.05	Coeff.	2.6
	t-stat	.03	t-stat	1.12
mpc/g.1	R^2 (%)	0	R^2 (%)	1.4
	Coeff.	–.07	Coeff.	3.5
	t-stat	–.02	t-stat	1.01
ppc/g.1	R^2 (%)	0	R^2 (%)	1.5
	Coeff.	–.07	Coeff.	3.42
	t-stat	–.03	t-stat	1.03
mpc/g.m	R^2 (%)	.1	R^2 (%)	2
	Coeff.	.61	Coeff.	3.2
	t-stat	.28	t-stat	1.18
ppc/g.m	R^2 (%)	.1	R^2 (%)	2
	Coeff.	.52	Coeff.	3.08
	t-stat	.27	t-stat	1.2

NOTE: This table displays the results for the regressions with the trade performance metric from 1980 to 1985 as the dependent variable and 12 different versions of the defense-competing metric as the independent variable. The first two columns of results reflect the defense-competing metric assuming all occupations are supply-constrained for the six combinations of final demand elasticity figures listed on the left-hand side. The last two columns show the same results using only a subset of occupations that are assumed to be supply-constrained.

Each of the flat rectangles indicates a step in the data transformation. Fig. 4.2 begins with the actual increase in defense spending. The final result in Fig. 4.5 is "Poor Performance in International Trade," a result that was not demonstrated by the research. Therefore, some step in the hypothesized chain of events did not happen, or the effect was too small to measure. A summary of the assumptions underlying each of the steps provides some potential reasons as to why there was no observable effect of defense spending.

Steps 1 and 2

The analysis begins with the actual data on defense spending from the budget. Two transformations convert this original round of spending increases into direct demand for industries, and into increases in total demand by industry (see Fig. 4.2). These calculations depend upon the accuracy of the coefficients in the Defense Translator Tables and in the Total Requirements tables. There is no reason to believe that these tables are not accurate representations of the production process as it existed in the early 1980s.

Table 4.3

Regression Results, 1980–1986

Elasticity Combination	All Occupations		Skilled Occupations	
mpc/g.0	R^2 (%)	.5	R^2 (%)	3
	Coeff.	1.15	Coeff.	3.7
	t-stat	.61	t-stat	1.4
ppc/g.0	R^2 (%)	.5	R^2 (%)	3.1
	Coeff.	1.03	Coeff.	3.5
	t-stat	.637	t-stat	1.5
mpc/g.1	R^2 (%)	.5	R^2 (%)	2.7
	Coeff.	1.71	Coeff.	4.7
	t-stat	.64	t-stat	1.4
ppc/g.1	R^2 (%)	.5	R^2 (%)	2.7
	Coeff.	1.48	Coeff.	4.5
	t-stat	.61	t-stat	1.4
mpc/g.m	R^2 (%)	1.1	R^2 (%)	3.2
	Coeff.	1.86	Coeff.	4.0
	t-stat	.89	t-stat	1.5
ppc/g.m	R^2 (%)	1	R^2 (%)	3.2
	Coeff.	1.6	Coeff.	3.8
	t-stat	.85	t-stat	1.53

NOTE: This table displays the results for the regressions with the trade performance metric from 1980 to 1986 as the dependent variable and 12 different versions of the defense-competing metric as the independent variable. The first two columns of results reflect the defense-competing metric assuming all occupations are supply-constrained for the six combinations of final demand elasticity figures listed on the left-hand side. The last two columns show the same results using only a subset of occupations that are assumed to be supply-constrained.

However, the calculations using the Input-Output tables are likely to underestimate the flexibility of the economy to changes such as the increase in defense spending. Input-output tables such as the Total Requirements table are based on a highly simplified characterization of the production process. The "recipe" for the production of every product is assumed to be rigidly fixed: to make one unit of A, one needs so many units of B, so many units of C, so many units of labor of type D, and so on. These production "coefficients" are recorded in the input/output tables estimated by the Department of Commerce. It would be possible to make this output in other ways in different circumstances. But since these other circumstances do not exist and generally have not existed, it is not possible to actually observe these other mixes of inputs. Therefore, it is necessary to assume that changes in outputs will require proportional changes in the inputs industries are using today.

One way in which this assumption could lead to an overestimate of inputs is the existence of economies-to-scale. For a variety of reasons, it may be possible to increase the production of certain products, for instance automobiles, from 50 to 100 without doubling the

Table 4.4

Regression Results, 1980–1987

Elasticity Combination	All Occupations		Skilled Occupations	
mpc/g.0	R^2 (%)	0	R^2 (%)	1
	Coeff.	–.25	Coeff.	2.05
	t-stat	–.14	t-stat	.85
ppc/g.0	R^2 (%)	0	R^2 (%)	.9
	Coeff.	–.3	Coeff.	1.8
	t-stat	–.2	t-stat	.81
mpc/g.1	R^2 (%)	0	R^2 (%)	.9
	Coeff.	.003	Coeff.	2.6
	t-stat	.001	t-stat	.81
ppc/g.1	R^2 (%)	0	R^2 (%)	.9
	Coeff.	–.2	Coeff.	2.4
	t-stat	–.08	t-stat	.8
mpc/g.m	R^2 (%)	0	R^2 (%)	1.2
	Coeff.	.4	Coeff.	2.3
	t-stat	.2	t-stat	.93
ppc/g.m	R^2 (%)	0	R^2 (%)	1.1
	Coeff.	.18	Coeff.	2.1
	t-stat	.1	t-stat	.89

NOTE: This table displays the results for the regressions with the trade performance metric from 1980 to 1987 as the dependent variable and 12 different versions of the defense-competing metric as the independent variable. The first two columns of results reflect the defense-competing metric assuming all occupations are supply-constrained for the six combinations of final demand elasticity figures listed on the left-hand side. The last two columns show the same results using only a subset of occupations that are assumed to be supply-constrained.

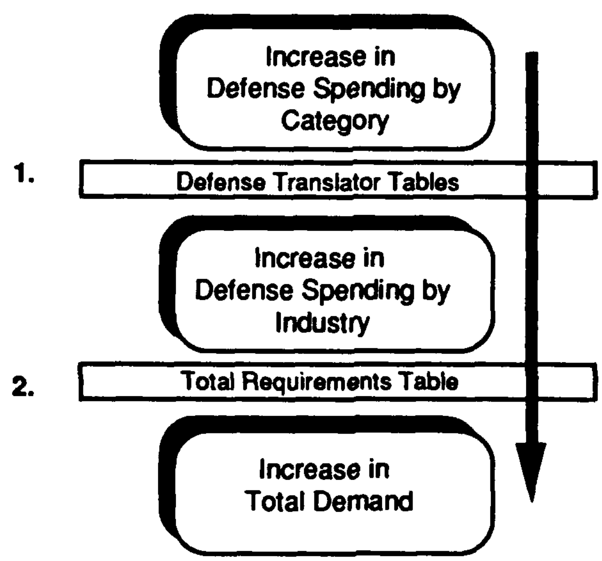

Fig. 4.2—Increases in Demand

inputs of steel, machinery, electricity, etc. Input-output tables imply that all industries exhibit constant returns to scale.

As a result of this simplification, the intermediate inputs required to supply the defense buildup may have been overestimated. However, this overestimate will not necessarily bias the results. The bias would occur only if the overestimate varies systematically with the order of the industries in the defense-competing metric. For example, if economies-to-scale are especially important in the industries that have high levels of the defense-competing metric, this would result in an upward bias in our estimates of the metric for those industries. The increases in costs due to higher wages might be offset by the scale economies provided by increased demand.[7]

These calculations are also based on the assumption—almost certainly contrary to reality—that demand for any product is insensitive to the price for other products. In the case of complimentary goods, so-called cross-price elasticities are actually negative: an increase in the cost of gasoline will decrease demand for automobiles. When goods are substitutes, cross-price elasticities will be positive: an increase in the costs of automobile ownership will increase usage of public transit. While many cross-price elasticities are not zero, these must be ignored. It is already a tall order to develop estimates of own price elasticities for a detailed disaggregation of total output. In order to develop estimates of cross-price elasticities, the data requirements for the model would grow as the square of the number of sectors, and rapidly growing data needs would quickly render any detailed analysis intractable. The consequence of ignoring cross-price elasticities will probably be that the estimates of the consequences of changes in defense spending will be overly concentrated in a few sectors.

As a result of this simplification, there may be an upward bias in the prices of certain intermediate products. This could occur because substitution is most likely to occur from intermediate inputs that have increased substantially in price. Both the defense producers and the defense-competing industries are likely to utilize substitutes for those intermediate inputs that have the largest increases in prices. Therefore, these intermediate inputs are likely to rise more slowly in price than is indicated by the model, and the substitutes are likely to have somewhat larger increases in prices. This would lead to an upward bias in the estimated costs of defense-competing industries, and a downward bias in the industries that use substitutes for these products. Therefore, the actual price increases that result from

[7]Anecdotal evidence suggests that economies-to-scale (or large minimum efficient scale) may be important in high-technology industries such as aircraft or electronics production.

defense spending are likely to be less concentrated in the defense-competing industries than the calculations suggest.

The models also fail to take into account the fact that changes in defense spending will change the real income of non-defense consumers and that these changes in income will affect consumer demand, to varying degrees, for all goods. These income effects are ignored for reasons of analytic tractability. Generally, changes in income resulting from changes in defense spending will not be large. The categories of defense spending that are the subject of the analyses, Procurement and RDT&E, increased from 1.54 percent of GNP in 1980 to 2.18 percent of GNP in 1983.[8] Therefore, the increases are on the order of one-half of 1 percent of GNP. Ignoring the income effects associated with changes of this magnitude will probably not introduce important errors. This is especially true since the incremental purchases by consumers are unlikely to occur in a concentrated set of industries.

Step 3

The second stage of the analysis is the estimation of the increase in demand by occupation (see Fig. 4.3). The problems that could be introduced in this step are similar to those mentioned above. Inaccuracies in the labor requirements table are possible, but more importantly, the labor requirements table assumes the same type of fixed coefficients as the input-output tables. In practice, economies of scale in the use of labor are possible. No more design engineers, for example, are likely to be needed to increase production runs of, say, computers or aircraft. Neither must management staffs, accounting departments, and other "overhead" functions expand proportionally with production. In this most recent buildup, for

3.

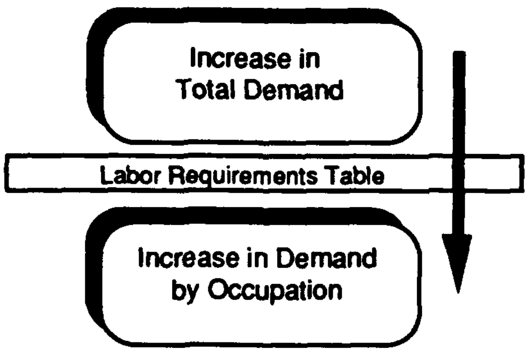

Fig. 4.3—Increase in Demand by Occupation

[8] *Historical Tables of the U.S. Budget, 1990,* and *Economic Report of the President, 1990.*

example, a large share of the procurement funds were used to purchase aircraft, missiles, and other systems that had been designed and were already in production. Increases in funding for production would necessarily increase the demand for production-related positions. However, increased production is unlikely to have much effect on the design staffs or on the overhead positions. Therefore, it is possible that the demand for workers in these occupations is overestimated.

Substitution is also likely among labor inputs, especially as a result of significant wage increases. If certain kinds of labor are in short supply, firms will figure out how to get by—perhaps less efficiently—with other kinds of labor. As a result, this step is also likely to lead to overestimates of the increases in demand by occupation, and overestimates of the increased costs for the entire range of defense-competing industries. Although this would lead to a greater range in the defense-competing metric, there is no evidence to suggest that this would bias the results of the regressions.[9]

Step 4

There are a number of important assumptions introduced in this stage of the analysis by the labor supply model (see Fig. 4.4). One is that the supply of workers within various occupations is fixed over the period of the analysis and that the workers cannot work additional overtime hours.[10] This assumes that the workers with particular skills were fully employed at the beginning of the defense buildup, and that workers in specialized occupations were not released from other industries during this period for reasons unrelated to the increase in defense spending. In fact, indicators such as capacity utilization and the unemployment rate indicate that some workers were probably unemployed in 1980, and that many more were probably made available by the downturn in business activity from 1980 to 1983. Capacity utilization in manufacturing dropped by 6 percentage points from 1980 to 1983 despite the increase in defense spending, and the unemployment rate increased by 2.5 percentage points during the same period.[11]

A related assumption implicit in the labor supply model is that the additional workers can only be made available from industry production for public or private consumption. It is possible that total investment demand may have been reduced as a result of the increase in

[9]As in the case of the estimates of elasticity of labor, evaluating the assumptions about labor substitution resulting from increased wages is beyond the scope of this study.

[10]Data from the U.S. Department of Labor, Bureau of Labor Statistics' *Employment, Hours, and Earnings* do not show any sharp increase in the hours worked in the highest defense-competing industries over this period.

[11]*Economic Report of the President*, February 1990, Tables C-51 and C-32.

4.

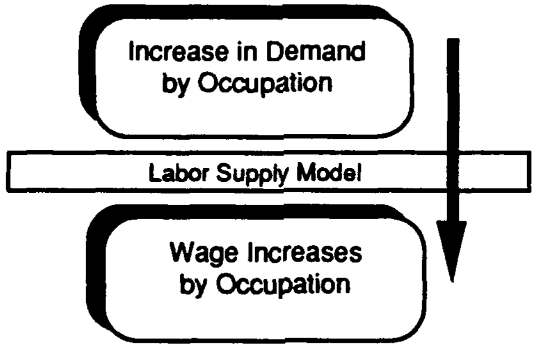

Fig. 4.4—Labor Supply Model

defense demand and the resulting higher wages for workers. Investment includes purchases of plant and equipment by business, and purchases of housing by individuals. A large percentage of certain industries' production is designated as investment, and in the model, workers could not be drawn from this source. Nearly all of the production of the construction industry, for example, is designated as investment. Other industries which produce a significant amount for investment include the machinery industries, transportation industries, and a number of the high-technology industries. If workers were also squeezed out of production for investment as well as production for consumption, the calculations would have underestimated the availability of skilled workers in the economy. In fact, the level of gross private fixed investment did fluctuate over the period, as shown in Table 4.5.

This study is also based on the assumption that increased defense spending will lead to higher wages. However, it is not necessarily true that sharply increased defense demand will lead to higher wages, even if workers within those occupations are in short supply.

Table 4.5

Gross Private Fixed Investment, 1980–1986

Year	Gross Private Fixed Investment (billions of 1982 dollars)
1980	506
1981	547
1982	447
1983	503
1984	664
1985	650
1986	631

SOURCE: *Economic Report of the President*, February 1990, Tables C-2 and C-3.

While some authors found that salaries did respond to increases and decreases in defense demand,[12] other research indicates that the increased domestic demand may lead to increased backlog or less attention to exports. For example, Gregory suggests that internal demand increases may lead to lower levels of exports even if wages are not greatly affected.[13] These exports might occur as a result of less generous credit terms and a generally less enthusiastic response of suppliers to exports. Artus[14] found that an increase in domestic demand led to an increase in backlog for export orders. These findings suggest that trade performance might be negatively affected even if wages do not increase significantly.

Finally, the labor supply model assumes that entry into certain occupations is strictly limited. This is also unrealistic, since it is likely that promotion and training occur more rapidly when the wages of a certain type of worker increase. The model included only infinitely elastic and completely inelastic occupations—the actual labor supply elasticities are obviously between these two extremes.

These factors suggest that significant numbers of skilled workers may have been available from sources other than from production for final demand. As a result, the effect of defense spending on occupations and on industries would be smaller than estimated, but does not necessarily indicate that the order of the defense-competing industries is inappropriate. The effect of these assumptions implicit in the labor supply model is to overestimate the wage increases that will result from the increase in defense spending, and widen the range of the defense-competing metric.

Steps 5 and 6

The final steps of the model involve some additional assumptions (see Fig. 4.5). The first is that increased costs due to higher wages will be converted into increased export prices for each industry.

A second assumption is that these increased prices will lead to observable changes in the performance of those industries in international trade. For example, this research is based on the assumption that export revenue will decrease and import revenue will increase as a result of an increase in the price of exports. The extent of the increase and decrease depend upon the elasticities of demand for exports and imports. For example, if the demand for exports is relatively inelastic ($|\varepsilon| < 1$), export revenue would actually increase as a result

[12] Freeman 1975, p. 27.
[13] Gregory 1971, p. 28.
[14] Artus 1973, p. 31.

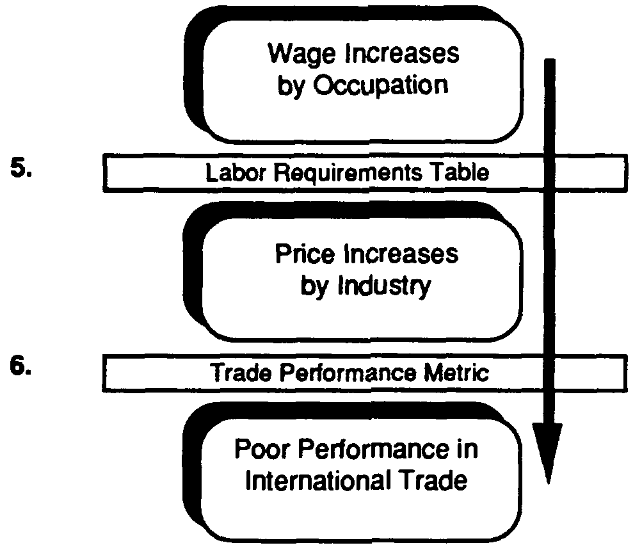

Fig. 4.5—Final Steps of the Model

of higher prices. Trade statistics based on quantities rather than revenue would help alleviate this problem, but these are not available. Therefore, this research relies on the assumption that export and import demands are relatively elastic ($|\varepsilon| > 1$). Further, the elasticities cannot be correlated with the defense-competing metric.

For example, if the elasticities of demand in international trade for products of "defense-competing" industries were significantly lower than for non-defense-competing products, this could produce the lack of relationship, even if all the steps up to this point produced correct results. Trade elasticity estimates are not available to the extent necessary to fully test this assumption, but it does not appear that this type of correlation exists.[15]

Assessing These Shortcomings

One of the likely effects of these assumptions is to overestimate the effect of defense spending. This would have the effect of "widening" the scale of the defense-competing metric. This can be illustrated by a comparison of the defense-competing results between those that were calculated with the assumption that all occupations are characterized by inelastic supply, and those calculated with the assumption that only certain occupations were supply constrained. The order of the industries is not much different (R^2 of .941, see Fig. 2.6), but the range of the metric may increase as a result of the more restrictive assumptions. This is illustrated in Fig. 4.6, where the plots show that the restrictive assumption (top) not only

[15]See Appendix A for a discussion of the elasticity data.

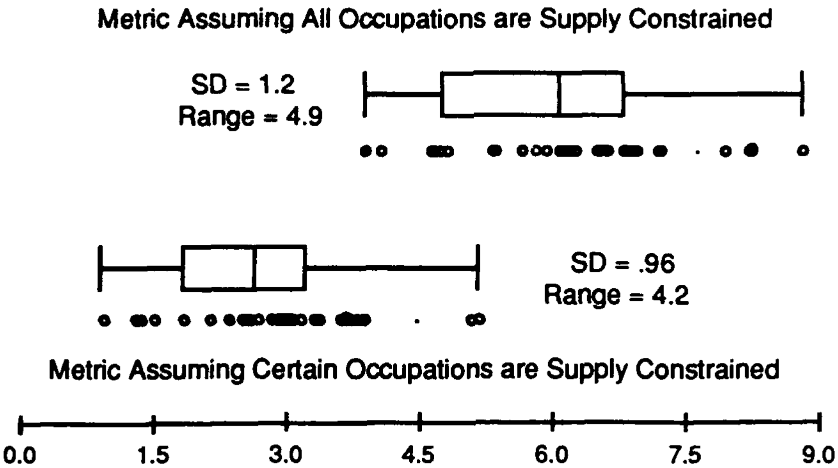

Fig. 4.6—Assumptions Leading to a Wider Range

shifts the metric results to higher levels, it also increases the spread of the results as indicated by the higher standard deviation and larger range. The assumptions that may lead to this type of result are listed in Table 4.6.

Influence of Other Factors

One of the possible causes for the lack of a measurable effect of defense spending on trade performance is that noise in the various data sources swamped any effects of defense spending. One of the ways in which noise might be generated is through the use of a "grain" of analysis which is too large. For example, if defense spending has an impact on some small section of the "radio and TV communications equipment" industry, then the greater the aggregation of the industry, the less chance there will be to observe that impact. In fact, the size of the "radio and TV communications equipment" industry suggests that the grain-size used may be too large. Communications equipment which is similar to that used by the defense industry is only a small part of the industry. Radios and televisions are also

Table 4.6

Assumptions Potentially Leading to Overestimated Results

Step	Assumption
2	constant returns to scale
3	constant returns to labor
3	no substitution among labor types
4	fully employed, fixed labor supply
4	labor squeezed only from final demand

included, as are records, cassette tapes, and telephone and related products. The shifts in trade that could occur due to changes in tastes or company fortunes in these other sections of the industry could easily swamp the effects of an increase in wages in the communications equipment part of the industry.

Other aspects of the research might also allow noise to be introduced into the measurement of either the costs or the trade performance of industries. A wide range of factors other than the influence of defense spending is likely to have influenced costs during this period, and therefore added noise to the analysis. These factors might include large energy and other input price changes, environmental or other regulatory costs, and shifts in labor markets. There is also a range of factors that might have introduced noise into the trade performance measures. These might include foreign government support of export industries or restriction of imports, trade shifts due to exchange rate shifts, trade shifts due to changes in tastes, and variance in the elasticities of demand for imports and exports. If the noise generated by these factors is not systematically related to the measurement, then it will simply require a more sensitive instrument to distinguish between the noise and the signal. However, if the noise is somehow correlated to either the defense-competing or trade performance measures, this might lead to a bias in the analysis. For example, if foreign governments sharply increased their subsidies to industries that export defense equipment, this would create a form of bias in the trade measure. The measure would indicate that imports performed better than exports, even if the U.S. defense buildup did not have a negative impact on the trade performance of industries.

POTENTIAL POSITIVE EFFECTS OF DEFENSE SPENDING

One potentially interesting source of bias might result if defense spending has positive effects on industry trade performance. One way in which this might occur is through economies-to-scale. The regression results described above provide an indication that there are no large beneficial effects of defense spending for the defense-competing industries. These regressions show that trade performance is neither positively or negatively related to the defense-competing metric. However, the industries in the defense-competing industries were selected using specific criteria based on estimates of the higher costs that would accrue due to competition for labor inputs. Therefore, the defense-competing metric is not the best measure to use in a test of the positive impacts of spending.

A more appropriate test of the positive effects of defense spending is based on the performance of a different set of industries. Since the beneficial effects might be based on economies-to-scale, a test of the positive contribution of defense spending would compare the

trade performance of industries to a measure of defense spending's contribution to scale economies in individual industries. A measure of the contribution of defense spending to economies-to-scale for each industry was constructed using the dollar value increase in defense spending from 1980 to 1983 divided by the total output of the industry in 1980. The potential positive contribution of defense spending to industry trade performance was tested by regressing the measures of trade performance on this variable measuring the impact of defense spending. If increases in defense spending lead to improved trade performance, this regression would produce positive coefficients. As indicated in Table 4.7, the regressions based on the change in trade performance from 1980 through 1984, 1985 or 1986 show statistically significant results. These mixed results provide some support for the hypothesis that defense spending may have the effect of improving trade performance, possibly through the mechanism of providing economies-to-scale.

Table 4.7

Tests for Positive Effects of Spending

Trade Performance Period	Regression Results	
1980–1984	R^2 (%)	6.5
	Coeff.	75
	t-stat	2.2*
1980–1985	R^2 (%)	4.3
	Coeff.	66
	t-stat	1.76*
1980–1986	R^2 (%)	5.3
	Coeff.	73
	t-stat	1.97*
1980–1987	R^2 (%)	2.3
	Coeff.	45
	t-stat	1.27

NOTE: This table displays the results for the regressions with the increase in total defense demand as a percentage of industry size as the independent variable, and the various trade performance metrics as the dependent variables.

An asterisk indicates that the results are significant at the .05 level with 33 degrees of freedom.

5. CONCLUSIONS

IMPLICATIONS

The study results do not demonstrate any relationship between the degree to which an industry competes with defense production for scarce labor resources and the trade performance of that industry. Consequently, the results do not demonstrate any particular link between the rise in U.S. defense spending during the early 1980s and the poor U.S. high-tech trade performance during that same period. To the extent, of course, that increased defense spending contributed to larger federal deficits and in turn to higher dollar interest rates, it contributed to the overall disappointing U.S. trade performance during the 1980s. But in this regard, defense spending is no different from any other form of government spending, or from private consumer spending.

The aim in this research has been to test whether increased defense procurement might have had some additional effect on the trade performance of particular U.S. industries beyond what would be expected from any government spending. Defense procurement was the focus of the study because it generates increased demands for resources in scarce supply. There was no apparent effect.

The most important implication of this negative finding is that there appears to be no basis for hoping that current and future reductions in defense spending will lead to an improvement in the trade performance of high-technology U.S. industries. Increased defense spending does not appear to have been an important contributor to the decline in the trade performance of these industries. There seems to be no reason to expect that declining defense spending will contribute to improved performance. Policymakers concerned about U.S. high-tech industries and their competitiveness in international markets should look elsewhere for the causes of current difficulties and sources of future hope.

This research may also have implications for the current debate regarding future defense strategy. One option being considered is to continue research and development and postpone the large-scale production of the resulting systems until needed. The buildup of the early 1980s was a type of "dry run" for such a strategy, involving a surge in production of systems that had been largely designed in prior years. Since the buildup had no measurable effect on the trade performance of U.S. industries, it suggests that production surges are unlikely to have negative impacts on the trade performance of high-technology industries unless the conditions are substantially different from those of the early 1980s.

INTERMEDIATE RESULTS

A number of the intermediate results produced by this research may be of policy interest. For example, this research confirms that the industries that are most likely to be affected by defense spending are among those that are typically considered high-technology industries. The industries listed as high-technology by the Department of Commerce based on the amount of embodied research and development are similar to the industries at the top of the "defense-competing" list.[1]

A listing of the occupations which are likely to have the largest percentage of wage increases as a result of the defense buildup is also an intermediate finding of interest. The ranking of occupations takes into account the additional demand due to defense spending and the availability of those workers in private industry. Therefore, larger wage increases would be expected either when there are few of that type of worker in private industry, or when higher wages for those workers are unlikely to decrease demand for industry output.

Finally, the trade performance measure provides an indicator of the best and worst performers in international trade. The trade deficit is an important economic measure for both the economy and for individual industries, but the measures developed in this research are more useful in an assessment of performance across a number of industries.

ADDITIONAL RESEARCH

A number of interesting follow-on research efforts are suggested by this research. The focus of this research has been on the *effects* of defense spending on trade performance. A closer examination of the individual steps involved in testing this hypothesis will provide additional insight into the *mechanisms* through which defense spending might affect economic performance. A number of the assumptions of the research can be tested through a comparison of the intermediate results of the research with available economic data.

One research effort would be to more closely examine the effect of defense spending on wages. Certain types of employment-related information are available to address this question. These include employment and hours by industry, wages by industry, and some additional information regarding entry and exit into specialized fields of science and engineering. Although these data sources do not coincide directly with the intermediate results produced in this research, they can provide some indication of the difference between the actual data and the predicted results regarding the employment effects of the increase in defense spending.

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[1]L. Davis, 1982.

A second way to study further the mechanism through which defense spending might affect economic performance is through an examination of the effects of the wage and price increases on the composition of trade. Although trade performance was not significantly affected by the defense buildup, there are a number of potential reasons that this did not occur. One is that there were no significant increases in wages and prices. Alternatively, however, the increases in wages and prices may not have had an effect on trade performance. Therefore, it would be useful to examine the mechanisms by which price increases are translated into trade performance. Export and import price indexes for the United States are available for certain industry groups for the period of interest. These indexes could be used as a source of information to compare with the price increases suggested by the defense-competing metric. This comparison would provide an indication of whether the export prices did increase as a result of defense spending. If export prices did increase, these indexes could also be used to examine the effects of the price increases on the trade performance of industries using the trade metrics.

A third follow-on effort would be to review the data from previous increases in defense spending such as the Vietnam buildup to look for similar effects. This is a useful comparison since one of the key questions raised by the findings is whether the recession that was occurring during the early 1980s might have counteracted the effects of defense spending. Since the defense spending for the Vietnam War occurred during a period of relatively high-capacity utilization, it would be valuable to apply the current methods and measures to that situation.

Finally, the mixed results of the tests for positive effects of defense spending suggest that there may be some mechanism by which defense spending might improve trade performance. This study generated some of the data and performance measures which made these tests possible. However, a more rigorous test of this hypothesis would be necessary to determine with any confidence that defense spending did have a positive impact on trade performance. In addition, further research might also provide other explanations of why defense spending might improve the trade performance of an industry.

Appendix A

A METRIC FOR DEFENSE-COMPETING INDUSTRIES

This appendix describes the metric that has been developed[1] to estimate the increase in costs that is likely to result from an increase in defense spending. The first element of this model is a set of input-output style, fixed-coefficient production relations. Let A_{ij} denote the amount of good i needed to produce one unit of good j. Let F_i denote the final non-defense demand for good i and D_i the final defense demand for good i. If Q_i denotes the total production of good i, market clearing in goods markets then requires that

$$Q_i = \sum_j A_{ij}Q_{j3} + F_i + D_i \tag{A.1}$$

for each of n goods. In matrix notation,

$$\mathbf{Q} = \mathbf{AQ} + \mathbf{F} + \mathbf{D}. \tag{A.1a}$$

(Throughout this study, bold-faced letters will denote matrices and vectors.) If $(\mathbf{I} - \mathbf{A})$ is nonsingular, equation (A.1a) can be rewritten as

$$\mathbf{Q} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{F} + \mathbf{D}).$$

Letting lower case letters denote changes in the vectors represented by upper case letters

$$\mathbf{q} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{f} + \mathbf{d}). \tag{A.1b}$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is the so-called total requirements matrix published regularly by the U.S. Commerce Department as part of its standard input-output exercise. It denotes the total change in the vector of outputs $\mathbf{Q}$ necessary to satisfy a change in the vector of final demands $(\mathbf{F} + \mathbf{D})$.

Let us further assume that there is a fixed supply of each of m kinds of labor, denoted by L_i. Let B_{ij} denote the amount of labor of type i required to produce one unit of good j. Labor market clearing requires that

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[1]Developed by C. R. Neu. See L. Yager and C. R. Neu, RAND, R-4126, 1991.

$$\sum_j B_{ij}Q_j = L_i \qquad \text{(A.2)}$$

for each type of labor L_i. In matrix notation,

$$\mathbf{BQ} = \mathbf{L}. \qquad \text{(A.2a)}$$

The U.S. Labor Department publishes occasional estimates of the matrix **B**, the amounts of various types of labor employed in different industries. Writing (A.2a) in difference form and remembering that the labor supply vector **L** is fixed,[2]

$$\mathbf{Bq} = \mathbf{0}. \qquad \text{(A.2b)}$$

Substituting (A.1b) into (A.2b),

$$\mathbf{B(I - A)^{-1}(f + d) = 0}, \qquad \text{(A.3)}$$

which says that any extra labor required to satisfy a change in defense demand, **d**, must be freed by offsetting reductions in non-defense demand, **f**.

For convenience, let us introduce a new matrix

$$\mathbf{C = B(I - A)^{-1}}, \qquad \text{(A.3a)}$$

which can be interpreted as a matrix of total labor requirements. If competition in the economy suffices to keep profits equal to zero,[3]

$$P_i = \sum_j C_{ji}W_j, \qquad \text{(A.4)}$$

where P_i is the price of good i, and W_j is the wage for labor of type j. In differential form,

$$p_i = \sum_j C_{ji}w_j. \qquad \text{(A.4a)}$$

To complete the model, assume that the vector of final defense demands **D** does not depend on prices, being determined instead by some estimates of "national security requirements." The vector of final non-defense demands, **F**, however, does depend on prices. For simplicity, assume that all cross-price elasticities are zero, such that only the price of

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[2]In one set of calculations of this metric, we have assumed that only skilled occupations are in fixed supply. Demand for workers in other occupations may still increase, but will not lead to wage increases and therefore have no effect on industry costs.

[3]We could equally well assume that profits are a constant fraction of input costs.

good i affects demand for good i and ignore income effects on the vector of non-defense demands.

It is now possible to calculate the metric of defense competitiveness. First, note that an increase in the wage for labor of type j (denoted by w_j) will, by equation (A.4a) result in a price increase for good k of $w_j C_{jk}$. This price increase will reduce demand for good k by $w_j C_{jk} f_k$, where $f_k = \partial F_k / \partial P_k$

This reduction in final demand for good k in turn implies a reduction in demand for labor of type j, by equation (A.3) of

$$w_j C_{jk}^2 f_k . \tag{A.5}$$

What is true of industry k will be true of all other industries, and the total decline in demand for labor of type j as a result of a wage increase will be the sum of effects stemming from all industries that use that type of labor. Thus the total change in demand for labor of type j will be

$$\sum_k w_j C_{jk}^2 f_k = w_j \sum_k C_{jk}^2 f_k .$$

An increase in demand for labor of type j as a consequence of increased defense spending must be offset by a decline in demand for labor of type j as a consequence of a decline in non-defense demand. The extra labor of type j required by changes d_k in the defense consumption vector will be $\sum_k C_{jk} d_k$. Thus,

$$w_j \sum_k C_{jk}^2 f_k = \sum_k C_{jk} d_k ,$$

or

$$w_j = \frac{\sum_k C_{jk} d_k}{\sum_k C_{jk}^2 f_k} . \tag{A.6}$$

Substituting equation (A.6) into equation (A.4a) yields an expression for the change, p_i, in the price of good i as a result of changes d_k in defense spending:

$$p_i = \sum_j C_{ji} \frac{\sum_k C_{jk} d_k}{\sum_k C_{jk}^2 f_k}. \tag{A.7}$$

Now note that

$$f_k = -\left(\frac{\partial F_k}{\partial P_k}\frac{P_k}{F_k}\right)\frac{F_k}{P_k} = e_k \frac{F_k}{P_k}, \tag{A.8}$$

where ε_k is the negative of the own price elasticity of non-defense final demand for good k. (In this formulation, ε_k will typically be positive.)

So far in the development of this metric, units have not been specified for F, D, f, and d. If the amounts that can be bought for one dollar in the base period are chosen as units (that is, before any changes in defense demand) the initial price for any good, P_i, is equal to one. Using this fact and substituting equation (A.8) into equation (A.7),

$$p_i = \sum_j C_{ji} \frac{\sum_k C_{jk} d_k}{\sum_k C_{jk}^2 e_k F_k}, \tag{A.9}$$

where the summation in the denominator is over all goods for which F_k is positive.

Because $P_i = 1$ for all i, $p_i = \frac{p_i}{P_i}$.

In other words, p_i is the percentage change in the price of good i. Therefore,

$$\frac{p_i}{P_i} = \sum_j C_{ji} \frac{\sum_k C_{jk} d_k}{\sum_k C_{jk}^2 e_k F_k}. \tag{A.10}$$

Equation (A.10) provides the metric of defense-competing industries: an indication of how much the price of a particular good will have to change as a consequence of changed input prices brought about by changes in the vector of defense spending. The more the price of an industry's output rises due to defense-related input price increases, the more directly that industry can be said to compete with defense industries.

Appendix B

DATA SOURCES FOR THE DEFENSE-COMPETING METRIC

The data used in this study are of four types: defense spending data, data on intra-industry sales (input-output tables), industry employment data (labor requirements matrix), and elasticity data. The sources for these four types of data are described in detail in this appendix.

DEFENSE SPENDING DATA

Two different data sources were used for the Procurement and the RDT&E budget figures. The *DMS Budget Reports*[1] were used for the Procurement component of this information. For example, the FY 1982 Defense Procurement Budget contains the outlay data at the level of detail necessary to allow conversion to detailed industry categories. Table B.1 shows an example of the data as it is provided in the budget reports.[2]

The RDT&E data were not required at the same level of detail for conversion to industry categories. As a result, service level data were utilized, and these data were available in the *Budget of the United States Government*, Fiscal Year 1982, Appendix.[3] An examp!^ of the data from this source is shown in Table B.2.[4]

Table B.1

Excerpts from Defense Procurement Budget (millions of $)

Army	FY-79	FY-80	FY-81
Aircraft Procurement			
Fixed Wing			
C-12A Cargo	—	12.2	—
RC-12 Guardrail	—	—	—
Rotary			
AH-1S Attack Helicopter	116.5	29.5	—
CH-47C,D	33.0	—	—
UH-60A Black Hawk	343.8	339	288.5

SOURCE: DMS, Inc., Defense Procurement Budget.

[1]DMS, Inc., *FY 1981 Defense Procurement Budget*, Greenwich CT., 1980. Similar reports were used for other years of the defense buildup.

[2]DMS, Inc., *FY 1981 Defense Procurement Budget*, p. 5.

[3]For example, the data for 1980 outlays were available in the *1982 Budget Appendix*, pp. I-G40 to I-G44. Line 90 (Outlays) was used consistently. Similarly, 1983 outlays were found in the 1985 Budget.

[4]*1982 Budget Appendix*, pp. I-G40 to I-G44.

Table B.2

Excerpts from the Defense RDT&E Budget

Research, Development, Test, and Evaluation, Army		
Program and Financing (in thousands of dollars)		
	Obligations	
	1980 Actual	1981 estimate
Program by Activities . . .		
. . .		
90.00 Outlays	2,707,031	2,941,000

SOURCE: Budget of the United States Government, Fiscal Year 1982, Appendix.

These two sources of data specify the dollar amounts of spending for the two accounts for 1980 and 1983. However, for these data to be useful for industry analysis, the dollar amounts by budget category had to be converted to dollars by industry category. This conversion is made possible with the "Defense Translator Tables." Translator tables allocating outlays for particular defense programs to specific industrial sectors have been created by the Office of the Secretary of Defense and the Institute for Defense Analysis (IDA) for the major Procurement and RDT&E accounts. For the purposes of this project, fifteen of these translator tables were used. Each of these tables includes anywhere from 1 to 12 categories of defense spending.[5] A section of one of the translator tables is shown in Table B.3.

The figures from the two sources of budget data are entered in the top row of the table, indicated in this section of the table with bold lettering. Each of these dollar amounts at the

Table B.3

Excerpts from Air Force Missiles Translator Table (millions of $)

			MX Missile	Tactical Missiles	Space Programs
Industry Code	Industry	Totals	**$0**	**$240**	**$345**
			0%	0%	0%
45	Missiles	$531	28%	28%	13%
46	Ammunition	$10	0%	2%	0%
161	Chemicals	$34	11%	6%	5%
271	Cutting Tools	$77	1%	0%	0%
272	Forming Tools	$22	0%	0%	0%
367	Air Transport	$3	2%	2%	2%

SOURCE: IDA *Defense Translator*, June 1984.

[5]These categories are based on those utilized in the IDA *Defense Translator*, Record Document D-62, June 1984.

top of the column is then divided into industry spending based on the percentages below. For example, 13 percent of the $345 million budget for space programs goes for purchases from the missile industry, industry code 45. Total purchases from the guided missile industry resulting from space programs and other components (columns) of the Air Force missiles translator table amount to $531 million. The column labeled Totals shows the total direct defense spending in each of the industries along the left column. (The totals in this excerpt of the entire table do not add since only a few of the columns and rows are shown).

An additional set of tables totals the purchases from each of the various translator tables to produce a single list of defense purchases by industry. The industry codes used in the translator tables are similar to the 4-digit Standard Industrial Classification System (SIC). However, the 4-digit SIC codes contain more industry detail than the other data sources used in this analysis. As a result, increases in spending by 4-digit SIC code must be converted to the industry classification required for the next step in the process, the input-output classification system. A concordance was created that added the totals for each 4-digit detailed SIC industry that is included in an input-output industry. For example, industry codes 45 and 46 shown in the above table, missiles and ammunition, were both allocated to the input-output industry 13, "ordnance and accessories."

This process was repeated for 1980 and 1983. The difference between the two columns of figures is the increase in defense spending in the year 1983 over the base year 1980. It is this additional demand that is traced through the economy.

INPUT-OUTPUT TABLES

The second type of data used for this project is the summary input-output (I-O) tables of the U.S. economy, produced by the Bureau of Economic Analysis, U.S. Department of Commerce.[6] Five different tables are produced for each year: the Make Table, the Use Table, the Direct Requirements Table, and the Commodity by Commodity and the Commodity by Industry Total Requirements tables. These summary level tables divide the economy into 79 industries.[7]

[6]For a complete description of the summary I/O tables, see for example, *Survey of Current Business*, "The Input-Output Structure of the U.S. Economy, 1977," May 1984. More detailed input-output tables are available from the Department of Commerce with considerably more industry detail. However, these tables offer few advantages for this project since supporting data are not available at a similar level of detail.

[7]There are advantages to using the summary level tables for this historical research, chiefly that the set of tables were available for the years of interest for the research. Detailed tables are available only for census years, and then with considerable delay.

The Use Table is one of the two tables used in this analysis. The Use Table shows the value of each commodity used by each industry, with the rows showing the distribution of output for the commodity and columns showing the composition of inputs to an industry. For example, the entry in the row i, column j of the Use Table shows the amount of intermediate inputs required by industry j from industry i. Additional columns of the Use Table provide the data regarding the composition of final demand. These columns provide an accounting of each industry's output broken down into intermediate use, personal consumption expenditures, gross private fixed investment, exports, imports, and federal and state/local government purchases. The 1981 table was used for the figures on final demand.[8] A section of the Use Table showing the final demand is shown in Table B.4.

The other I-O table that was used for this analysis was the Commodity by Industry Total Requirements Table. Each column of the Total Requirements table shows the inputs—both direct and indirect—required from each of the industries named at the beginning of the row for each dollar of output for the industry named at the top of the column. A section of the Total Requirements Table is presented as Table B.5.

For example, this table shows that for each dollar of final demand in the electrical machinery industry, 4.3 cents of direct and indirect spending is generated in the electronic components industry. The coefficients presented in this table allow the total impact of defense spending increases to be estimated, including not only the direct defense purchases from industries, but the additional purchases that are generated by the defense expenditure. For the purposes of this research, the Total Requirements Table also allows the estimation of the total labor requirements generated by defense spending.[9]

Table B.4

Excerpts from Input-Output Use Table (millions of $)

Industry	Personal Consumption	Gross Private Fixed Investment	Exports	Government Purchases
Electronic Components	529	35	2468	775
Electrical Machinery	2003	1491	859	305
Motor Vehicles	46124	30854	10963	3026
Aircraft and Parts	427	2777	7159	9803

SOURCE: *Survey of Current Business*, May 1984., p. 57.

[8]Unlike the coefficients in the Direct or Total Requirements tables, the values in the columns representing final demand change significantly from year to year.

[9]The Total Requirements Table corresponds to the matrix $(\mathbf{I} - \mathbf{A})^{-1}$ in equation A-1b in Appendix A.

Table B.5

Excerpts from Input-Output Total Requirements Table

Industry	Electronic Components	Electrical Machinery	Motor Vehicles	Aircraft & Parts
Electronic Components	1.034	.043	.007	.037
Electrical Machinery	.003	.964	.024	.005
Motor Vehicles	.005	.035	1.348	.007
Aircraft and Parts	.004	.001	.003	1.171

SOURCE: *Survey of Current Business*, May 1984., pp.76–77.

EMPLOYMENT DATA

The third type of data that is required for this analysis are data regarding the pattern and the level of employment by occupation and by industry. The Department of Labor has prepared the National Occupational Employment Matrix, a detailed matrix which describes the pattern of employment in the United States for the year 1986. This matrix is similar to the I-O Use Table except that the requirements by SIC industry are stated in terms of employees in various occupations rather than intermediate inputs. A section of the employment matrix is included as Table B.6.

Each SIC industry column shows the number of employees in each of the occupational categories represented by the rows. The occupational titles are highly detailed in this matrix; the full matrix contains 479 occupations[10] (rows) and 236 industries (columns). The industries along the top coincide with the SIC classification system.

Table B.6

Excerpts from Labor Requirements Matrix
(numbers of employees)

SIC Industry / Occupation	371 Motor Vehicles	372 Aircraft & Parts	376 Guided Missiles	379 Misc. Transport Equipment
Aircraft Assemblers	746	7055	2515	691
Electronics Assemblers	746	2838	645	691
Electromechanical equip. assemblers	0	0	0	0
Structural metal fitters	4634	2024	645	340
Machine builders	1743	5978	645	283

SOURCE: National Occupational Employment Matrix, 1986.

[10] The occupational titles have been shortened to allow their incorporation in this sample table. The full titles were Aircraft assemblers, precision; Electrical and electronic equipment assemblers, precision; Electromechanical equipment assemblers, precision; Fitters, structural metal, precision; and Machinery builders and other precision machine assemblers.

For this analysis, data had to be converted from numbers of workers (shown in Table 6) into workers per million dollars of industry output. The resulting table is similar to the Total Requirements Table shown in Table B.5, where each element is a coefficient representing the amount of input—in this case labor input—required from the occupational category (row) for each dollar of industry final demand represented by the column.

This modification was accomplished by collecting industry output figures for the year of the employment table. The majority of the output data by SIC code are available in the *Annual Survey of Manufactures* for 1986, published by the Bureau of the Census. The remaining industries are found in a variety of other sources, including the Census Bureau's *Census of Wholesale Trade*, *Census of Retail Trade*, and *Census of Service Industries*; the Department of Commerce's *U.S. Industrial Outlook*, and *Business Statistics* published by the Bureau of Economic Analysis.

In most cases, a close match is possible between the SIC codes that are included in the Occupational Matrix and the SIC codes in those publications. In certain service industries, output figures are not available at the highly detailed industry level, and in those cases, we have aggregated industries (columns) to the level of available data.

Identifying Supply-Constrained Occupations

One of the assumptions of the analysis is that growth in the labor force is severely limited in the short run. This assumption is embodied in the model as supply elasticities of zero for labor occupations. This assumption is more realistic for some occupations than for others, and as a result, we have tried to differentiate between occupations where the supply appears to be inelastic from those occupations where the supply appears to be more elastic. While it is beyond the scope of this project to calculate actual supply elasticities for the 479 occupations, it is possible to make a step in this direction by using information included in the Labor Department's *Occupational Outlook Handbook,*[11] the companion source to the Labor Department's occupational matrix.

The *Handbook* has detailed descriptions of most of the occupations used in the calculations, and each of these descriptions includes a section on "Training, Other Qualifications, and Advancement." In an effort to determine which occupations might be more realistically described as having a zero elasticity in the short run, three specific criteria were used to identify those jobs that might be characterized by inelastic supply:

[11]*Occupational Outlook Handbook*, 1986-87 Edition, U.S. Department of Labor, Bureau of Labor Statistics, April 1986.

1) Education: The purpose of this criterion is to identify occupations that require some form of specific educational training. Indicators of such requirements might include a mention of a specific course of study or degree at the bachelor's level, or more commonly, some advanced vocational training or a graduate degree. For example, engineering occupations were counted as having a specific education requirement because of the following: "A bachelor's degree in engineering is generally acceptable for beginning engineering jobs" (p. 60), or for psychologists: "A doctoral degree is often required for employment as a psychologist" (p. 105). However, specific educational training does not appear to be a prerequisite for Securities and Financial Services Workers, based on the following description: "a college education is increasingly important" (p. 264).

2) Experience: This criterion identifies those occupations with a specific mention of some form of apprenticeship or work requirement. A mention of informal on-the-job training was not considered sufficient for identifying an occupation as requiring specific work experience. Rather, we required a mention of some sort of formal experience needed in the particular job. For example, Electricians are counted as having a specific work experience requirement due to the following: "Most training authorities recommend the completion of a 4-year apprenticeship as the best way to learn the electrical trade" (p. 388). However, Bank Officers and Managers do not appear to have the same work experience requirement: "Many bank management positions are filled by promoting technically skilled personnel who have demonstrated the potential for increased responsibilities" (p. 27).

3) Licensing: The third criterion used was a requirement for some form of government license or certification procedure based on specialized training. For example, Aircraft Mechanics and Engine Specialists are considered to be in inelastic supply due to the following: "The majority of mechanics who work on civilian aircraft are licensed by the FAA as 'airframe mechanics,' 'powerplant mechanics' or 'aircraft inspectors.' The FAA requires at least 18 months of work experience for an airframe or powerplant license" (p. 335). However, licenses such as chauffeur's licenses for driving trucks or taxis were not considered as sufficient to indicate that workers in these occupations might be in inelastic supply.

Results Using Supply-Constrained Occupations

Table B.7 lists the occupations that have a specific educational, experience, or licensing requirement based on the criteria above. There are 67 occupations requiring specific educational training, 64 with specific work experience requirements, and 32 with licensing requirements. The number of occupations with one or more of these requirements is 130.

FINAL DEMAND ELASTICITIES

The final type of data used in this analysis is the set of price elasticities for final demand for the industries in the U.S. economy. The analysis assumes fixed coefficient production processes and inelastic supplies of labor. As a result, increased defense demand for workers can be met only by decreases in production for final demand. The final demand categories are personal consumption expenditures, gross private fixed investment, exports, and government purchases (see Table B.4). Elasticities for each of these final demand categories are necessary.

Personal Consumption Expenditures

This category is especially important as a percentage of the output of food products, apparel, and other consumer goods industries. Two sources provided suitable, although somewhat different estimates of the elasticities of final demand. Mansur and Whalley[12] present central tendency values for own-price elasticities of household demand functions in a recent book on the construction of general equilibrium models. All are uncompensated own-price elasticities.[13] Each of the 79 I-O industries used in this analysis was assigned on the basis of industry name, to one of the 23 industries for which Mansur and Whalley provide elasticity estimates (see Table B.8).

An additional set of own-price elasticities in consumption is presented by Petri.[14] The elasticities in this source are significantly lower across the board, and include estimates for 19 industries. The elasticity estimates from Petri and Mansur and Whalley are similar, however, in areas where personal consumption expenditures are a significant share of industry output.

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[12]Mansur and Whalley, 1984, p. 109.

[13]Uncompensated demand elasticities reflect the change in demand from changes in price uncompensated for the resulting change in income (Marshallian demand function). The compensated demand function (Hicksian) varies both price and income to maintain the consumer at a fixed level of utility.

[14]Petri, 1984.

Table B.7

Supply-Constrained Occupations

Occupation	Education	Experience	License
Education administrators	*	*	*
Public administration chief executives, legislative, and general administration	*	*	
Accountants and auditors	*		*
Inspectors and compliance officers, except construction			*
Construction and building inspectors			*
Management analysts	*		
Tax examiners, collectors, and revenue agents	*		
Underwriters	*		
Aeronautical and astronautical engineers	*		
Chemical engineers	*		
Civil engineers, including traffic engineers	*		
Electrical and electronics engineers	*		
Industrial engineers, except safety engineers	*		
Mechanical engineers	*		
Metallurgists and metal, ceramic, and material engineers	*		
Mining engineers, including mine safety engineers	*		
Nuclear engineers	*		
Petroleum engineers	*		
All other engineers	*		
Architects, except landscape and marine		*	*
Surveyors		*	*
Agricultural and food scientists	*		
Biological scientists	*		
Foresters and conservation scientists	*		
All other life scientists	*		
Statisticians	*		
Mathematicians and all other mathematical scientists	*		
Operations and systems researchers	*		
Chemists	*		
Geologists, geophysicists, and oceanographers	*		
Meteorologists	*		
Physicists and astronomers	*		
All other physical scientists	*		
Economists	*		
Psychologists	*		
Urban and regional planners	*		
All other social scientists	*		
Clergy	*	*	
Judges, magistrates, and other judicial workers	*		
Lawyers	*		*
Teachers, preschool			
Teachers, kindergarten and elementary	*		*
Teachers, secondary school	*		*
College and university faculty	*		*
Teachers and instructors, vocational education and training			*
Librarians, professional	*		
Counselors	*		
Dentists	*		*

Table B.7—continued

Occupation	Education	Experience	License
Optometrists	*		*
Pharmacists	*		*
Podiatrists	*		*
Physicians and surgeons	*		*
Registered nurses	*		*
Occupational therapists			*
Physical therapists			*
Speech pathologists and audiologists	*		
Veterinarians and veterinary inspectors	*		*
Dental hygienists			*
Emergency medical technicians	*		
Licensed practical nurses	*		*
Surgical technicians	*		
Electrical and electronic technicians/technologists	*		
All other engineering technicians and technologists	*		
Physical and life science technicians/technologists and mathematical technicians	*		
Air traffic controllers			*
Broadcast technicians			*
Programmers, numerical, tool, and process control		*	
Brokers, real estate			*
Sales agents, real estate			*
Real estate appraisers			*
Electricians		*	
Central office and PBX installers and repairers	*	*	
Frame wirers, central office	*	*	
Radio mechanics	*	*	
Signal or track switch maintainers			
All other communications equipment mechanics, installers, and repairers	*	*	
Data processing equipment repairers	*	*	
Electrical powerline installers and repairers	*	*	
Electronic home entertainment equipment repairers	*	*	
Electronics repairers, commercial and industrial equipment	*	*	
Station installers and repairers, telephone	*	*	
Telephone and cable TV line installers and repairers			
All other electrical and electronic equipment mechanics, installers, and repairers	*	*	
Industrial machinery mechanics	*	*	
Aircraft engine specialists		*	*
Aircraft mechanics		*	*
Boilermakers		*	
Jewelers and silversmiths		*	
Machinists		*	
Shipfitters		*	
Tool and die makers		*	
All other precision metal workers		*	

Table B.7—continued

Occupation	Education	Experience	License
Numerical control machine tool operators and tenders, metal/plastic		*	
Combination machine tool setters, set-up operators, operators, and tenders		*	
Drilling machine tool setters and set-up operators, metal and plastic		*	
Grinding machine setters and set-up operators, metal and plastic		*	
Lathe machine tool setters and set-up operators, metal and plastic		*	
Punching machine setters and set-up operators, metal and plastic		*	
Soldering and brazing machine operators and setters		*	
Welding machine setters, operators, and tenders		*	
Electric plating machine operators and tenders, setters, and set-up operators, metal and plastic		*	
Heating equipment setters and set-up operators, metal and plastic		*	
Metal molding machine operators and tenders, setters and set-up operators		*	
Nonelectric plating machine operators and tenders, setters and set-up operators, metal and plastic		*	
Plastic molding machine operators and tenders, setters and set-up operators		*	
All other metal/plastic machine setters, operators, and related workers		*	
Bindery machine operators, setters and set-up operators		*	
Letterpress setters and set-up operators		*	
Offset lithographic press setters and set-up operators		*	
Printing press machine setters, operators and tenders		*	
All other printing press setters and set-up operators		*	
Screen printing machine setters and set-up operators		*	
Head sawyers and sawing machine operators and tenders, setters and set-up operators		*	
Woodworking machine operators and tenders, setters and set-up operators		*	
Cutting and slicing machine setters, operators and tenders		*	
Dairy processing equipment operators, including setters		*	
Electronic semiconductor processors		*	
Extruding and forming machine setters, operators and tenders		*	
Painting machine operators, tenders, setters, and set-up operators		*	
Paper goods machine setters and set-up operators		*	
All other machine operators, tenders, setters, and set-up operators		*	
Aircraft assemblers, precision		*	

Table B.7—continued

Occupation	Education	Experience	License
Electrical and electronic equipment assemblers, precision		*	
Electromechanical equipment assemblers, precision		*	
Fitters, structural metal, precision		*	
Machine builders and other precision machine assemblers		*	
Electrical and electronic assemblers		*	
Aircraft pilots and flight engineers		*	*
Locomotive engineers			*
Captains and pilots, ship		*	*
Ship engineers		*	

Table B.8

Personal Consumption Elasticities

Industry	Own-Price Elasticity	Number of Studies	Variance
Agriculture and fishing	.468	86	.07
Coal mining	.950	3	.76
Other mining	.609	6	.13
Food	.494	72	.13
Drink	.607	32	.16
Tobacco	.507	19	.10
Mineral oils	.609	6	.13
Other petroleum products	1.589	8	.9
Chemicals	.724	5	.05
Metals	1.083	51	.48
Mechanical engineering	1.005	45	.48
Instruments	.972	42	.49
Electrical engineering	1.06	50	.44
Vehicles	.985	51	.44
Clothing	.458	61	.18
Wood, furniture, etc.	.969	53	.33
Paper, printing, publishing	.362	11	.02
Other manufacturing	.592	38	.09
Utilities	.659	20	.10
Transport	.977	28	.23
Banking and insurance	.642	4	.04
Housing services	.505	53	.29
Professional services	.961	50	.48

SOURCE: Mancur and Whalley, p. 109.

NOTE: The second and third columns provide an indication of the quality of the estimates. These additional data were not utilized in this research.

Exports

Estimates of export price elasticities are not as common as estimates of import price elasticities, and as a result, there was not a high level of detail in the number of industries

covered. The best available data are provided in Stern.[15] These estimates divide export industries into six groups by Standard International Trade Classification System (SITC). Additional detail is available from Houthakker.[16] These elasticity estimates are more detailed, but did not differ greatly from the estimates presented by Stern. Agricultural exports tended to have relatively low elasticities ($.5 < |\varepsilon| < 1$), while elasticities for manufactured goods were generally higher ($1 < |\varepsilon| < 2$).

Government Purchases

This category includes both federal government purchases and state and local government purchases. No readily available sources for government purchase elasticities could be found, so a range of elasticities have been incorporated into our analysis. The first set of calculations incorporates zero elasticities for all government purchases, which is the lower bound of the range of elasticities. Zero elasticities are consistent with government purchases that must meet fixed requirements and are therefore completely insensitive to price. A second case incorporated all unit elasticities, based on the assumption that the government purchases only as much as the budget allows. A third scenario applies different elasticities to different classes of government spending. We assume elasticities of zero for defense purchases and one for state and local maintenance-type purchases. Health purchases were also given an elasticity of zero since these are often determined by entitlement rather than by a fixed budget allocation.

Gross Private Fixed Investment

The fourth component of final demand is gross private fixed investment (GPFI). The entire output of the construction industry is considered GPFI, as is a smaller share of the output of a number of service industries. Although GPFI is not considered an intermediate input in the I-O tables, the fixed coefficient nature of the model that we are using would also suggest that the fixed costs of production are also part of the production recipe. As a result, elasticity values of zero were assumed for each of these investment components.

CONCORDANCES

The final type of data used in the calculation of the defense-competing metric is the set of concordances and crosswalks necessary to convert from one classification system to another. The 400-industry detail reflected in the defense translator tables and the 236-

[15] Stern, 1976.
[16] Houthakker, 1969.

industry employment matrix had to be converted to the 79-industry I-O classification format. This involved using a version of a published table of the SIC to input-output concordance,[17] which allowed many SIC groups to be incorporated into a single I-O industry.[18]

It was also necessary to utilize data with various levels of SIC detail, such as in the collection of output figures to match the 236 industries represented in the employment matrix. In some cases, the detail was greater than needed, and in others, the detail was less than required. Finally, some data sources have only a fraction of the data detail of the input-output tables. This was the case with most of the elasticity data. In these cases, one elasticity category was used for many I-O categories.

[17] *Survey of Current Business*, May 1984, pp. 80–84.

[18] Concordances can be of four types, one-to-one, many-to-one, one-to-many, and many-to-many. The first is ideal and entails no loss of data quality or detail. Many-to-one concordances lead to a loss in data detail but have the advantage that the detailed data can be added or averaged in the new category so that there is no loss in data quality. For example, defense purchases from "truck and bus bodies" and "automobiles" can be added and will accurately reflect the defense purchases of the broader category of "motor vehicles." On the other hand, if an aggregated industry must be divided into sub-industries as in a one-to-many concordance, there is no way to divide the total dollar value (unless additional information is available) except by assuming the detailed categories are equal, which is an unacceptable assumption. In other situations, the one-to-many concordance does not lead to a dead end. For example, when there is limited detail on elasticity data, it is possible to assume that individual industries within a more aggregated industry have a similar elasticity value. Many-to-many concordances occur when there is little coordination between the data categories, and makes it difficult to combine information from the two sources.

Appendix C

CALCULATIONS FOR THE DEFENSE-COMPETING METRIC

This appendix describes the calculations required for the defense-competing metric. The metric is reproduced here from equation A-10 in App. A.

$$\frac{p_i}{P_i} = \sum_j C_{ji} \frac{\sum_k C_{jk} d_k}{\sum_k C_{jk}^2 \varepsilon_k F_k} \qquad \text{(A.10)}$$

where

p_i/P_i is the percentage change in output price for industry i,

C_{ji} is the amount of labor of type j needed to produce a unit of good i, including all of the labor necessary to produce all of the intermediate products needed to produce i;

d_k is the change in defense demand for goods from industry k,

F_k is the total final demand for good k, and

ε_k is the negative of the own-price elasticity of final demand for good k.

Three components are computed separately before being incorporated into the model: d_k, the changes in defense demand; C_{jk}, the total labor requirements matrix; and ε_k, the weighted final demand elasticity for each of the 79 industries. This section documents both the concordance programs that are necessary to convert the data sources to compatible forms as well as the actual calculations that are performed.

THE INCREASE IN DEFENSE SPENDING

Equation C-1 shows the steps required in the calculation of the vector **d**.

$$\mathbf{d} = (\mathbf{K} \cdot (\mathbf{T} \bullet \mathbf{b}^{83})) - (\mathbf{K} \cdot (\mathbf{T} \bullet \mathbf{b}^{80})) \qquad \text{(C.1)}$$

where

d is the vector of increases in defense spending from 1980 to 1983 by industry for each of 79 industries,

K is a 79 x 400 concordance matrix that converts 4-digit SIC industries into I-O industries,

T is the 400 x 102 translator table that converts budget categories to Data Resources, Inc. (DRI) industry categories, and

$\mathbf{b}^{83}$ and $\mathbf{b}^{80}$ are (102 x 1) vectors of the defense budget outlays for 1983 and 1980.

As mentioned above, the first step is to convert the Procurement and RDT&E spending from the defense budget categories into industry categories (represented by the calculations inside the nested parentheses). This is performed by multiplying the budget figures **b** by the translator table **T**. The Procurement and RDT&E accounts are divided into 102 different spending categories within 15 sections. Each section accounts for a particular type of spending within a service. For example, the Navy has sections for aircraft procurement, weapons procurement, and shipbuilding and conversion. Within each section are the actual categories of defense spending, either single large weapon systems, or groupings of weapons or activities in a single area.[1] There are a total of 102 different categories.

The next step is a concordance program that converts the output of the translator tables by detailed industry code into dollars by I-O category. This concordance program can be represented as the product of the 79 x 400 matrix **K** and the 400 x 1 vector $(\mathbf{T} \bullet \mathbf{b})$. The **K** matrix contains only zeros and ones, and the ones indicate those DRI industries (columns) that correspond to the I-O industries. The product of **K** and $(\mathbf{T} \bullet \mathbf{b}^{83})$ could be referred to as $\mathbf{d}^{83}$, which represents the direct defense spending resulting from the Procurement and RDT&E accounts in 1983 for each of 79 I-O industries. The final step in the calculation is to subtract the 1980 from the 1983 $(\mathbf{d}^{83} - \mathbf{d}^{80} = \mathbf{d})$ spending to determine the increase in spending by industry for that period, although it is not a cumulative increase in spending. These listings of industries that supply the direct requirements of the Department of Defense are standard outputs of input-output analysis.[2]

THE TOTAL LABOR REQUIREMENTS MATRIX

The total labor requirements **C** that appears in the metric in three positions also requires a series of steps for calculation. The steps are shown in equation (C.2) and described below.

[1] Each section is a single table in the source document. For an example, see Appendix B.

[2] For examples of this use of input-output analyses, see for example Leontief 1965, or more recently, Henry 1987.

$$\mathbf{C} = (\mathbf{M} \bullet (\mathbf{B} \bullet \mathbf{Q})')' \bullet (\mathbf{I} - \mathbf{A})^{-1} \tag{C.2}$$

where

C is the 479 x 79 total labor requirements matrix,

M is a 79 x 225 concordance matrix that converts the SIC industries of the NationalEmployment Matrix into I-O industries,

B is the 479 x 225 original occupational matrix supplied by the Labor Department,

Q is a 225 x 225 diagonal matrix where each element is 1/(total industry output), and

$(\mathbf{I} - \mathbf{A})^{-1}$ is the 79 x 79 total requirements matrix of the Input-Output Tables as published by the Bureau of Economic Analysis.

The original labor matrix (B) is the occupational employment matrix provided by the Department of Labor for the year 1986. Each element in this matrix is an estimate of the number of workers in each occupation (row) for each industry (column). The source matrix consists of summary (105) and detail (479) occupations and summary (66) and detail (236) industries. For this project, a combination of summary and detailed industries was used with the detailed occupations. This resulted in a matrix of 479 detailed occupations for 225 industries.

A number of modifications were necessary for this matrix to be useful for this project. First, the elements in the matrix had to be converted from numbers of workers to workers per million dollars of industry output. The second step was to convert the industries in the employment matrix to the industries according to the I-O classification. The processes used to make these modifications are described in detail below.

Conversion to workers per million dollars of output

The conversion required an estimate of the dollar value of output for each of the 225 industries for the year 1986. In each case, the first step was to ensure a close match between the definition of the industry used in the labor requirements matrix and in the source that was used for the dollar value of output. The SIC equivalents of the labor requirements matrix industry categories were used to look up the value of industry output. This conversion is represented in Equation C-2 as multiplication of **B** by **Q**, a diagonal matrix with entries for each industry of 1/(total industry output). These figures were checked using

estimates of the employment figures (if available) in the dollar value source[3] against the total for each employment matrix industry. When the employment figures were not available for comparison, the employment per dollar ratio was checked to determine if it was in line with prior information. For example, prior information indicated that all industries would have a ratio of between 1 worker per million dollars of output (highly capital intensive industries such as petroleum refining) and 50 workers per million dollars of output (highly labor intensive services such as barber shops, newsstands, etc.)

There were a few industries where the data were not available to allow the use of the full detail available in the labor requirements matrix. These included construction, transportation, communication, utilities, and the industries included in finance, insurance and real estate. In these cases, the broader industry definitions and the corresponding vectors of occupational employment were used from the employment matrix, and output estimates of these broader aggregates were used from the sources listed in Appendix B.

Convert to the 79-Industry I-O classification system

This step requires two types of information:

- the concordance between the employment matrix 225 industry classification and the I-O 79 industry classification system
- the weights to be used when combinations of employment matrix industries map to the same I-O industry.

The concordance between the 225 detailed SIC industries and the 79 I-O industries usually involved combining a number of the detailed SIC industries into the more aggregated I-O industries. Although this involves a loss of industry detail, the quality of the resulting coefficients for the larger industry accurately represent the combined set of individual industries. This was accomplished by appropriately weighting the detailed SIC industries to create the new aggregate I-O industry.

For example, if the separate missiles (SIC 3761) and ammunition (SIC 3482) industries account for 75 percent and 25 percent, respectively, of the aggregate ordnance I-O industry, the labor requirements coefficients of the ordnance industry should reflect the larger size of the missiles industry. This is accomplished by creating a new coefficient for each labor category that is .75 times the missiles coefficient plus .25 times the ammunition

[3]Certain Census publications include employment data. The Bureau of Labor Statistics *Supplement to Employment and Earnings*, August 1988, was also used.

coefficient. Although some industry detail is lost in this concordance, the occupational requirements per million dollars will remain accurate for the aggregate industry.

The many-to-one concordance for all industries is accomplished through matrix multiplication. In this case, the entries in the concordance matrix include zeros, ones, and fractions where more than one SIC industry maps into one I-O industry. The fraction is based on the share of the individual industry's dollar value of the total value of industries that map into the I-O industry. Each row of the **M** concordance matrix will sum to one, so that the new I-O industry row will be a weighted combination of one or more SIC industries.[4]

In cases where the concordance between the industries is clear, the total value of the Labor industries mapping into the I-O industry was approximately equal to the I-O value. However, in two industries, federal government and state/local government industries, (I-O industries 78 and 79), the values and the resulting number of employees in those industries are substantially different.[5] As a result of comparisons with other employment data sources such as the Labor Department's *Employment and Earnings*, these two columns were scaled upwards.

Additional Steps to Create the C Matrix

The steps outlined above lead to the creation of the $(\mathbf{M} \bullet (\mathbf{B} \bullet \mathbf{Q})')'$ matrix, which is 479 x 79. In order to create the **C** matrix, this matrix is multiplied by the $(\mathbf{I} - \mathbf{A})^{-1}$ matrix, the total requirements matrix of the I-O tables. The result of this calculation is the **C** matrix, which represents the total labor requirements per million dollars of output for each of the 79 industries.

---

[4]If

$$K = \begin{bmatrix} .5 & .5 & 0 & 0 \\ 0 & 0 & .9 & .1 \end{bmatrix}$$

and

$$(B \bullet Q)' = \begin{bmatrix} 10 & 10 & 10 \\ 20 & 20 & 20 \\ 30 & 30 & 30 \\ 40 & 40 & 40 \end{bmatrix},$$

then the product will be a 2 x 3 matrix where the first row is an average of the first and second rows of the latter matrix, and the second row is .9 times the third row and .1 times the final row, or

$$K(B \bullet Q = \begin{bmatrix} 15 & 15 & 15 \\ 31 & 31 & 31 \end{bmatrix}.$$

[5]This was checked by multiplying the I-O dollar value and the sum of all the workers per dollar coefficients to get a total employment figure.

CALCULATION OF A COMPOSITE ELASTICITY TIMES FINAL DEMAND

The third component that is computed separately is the set of products of industry final demand and the corresponding elasticities. The calculation is shown in equation C-3 and described below.

$$e_k = \sum_i e_{ik} F_{ik} \qquad \text{(C.3)}$$

where

ε_k is the elasticity of final demand for each of 79 industries,

i indexes the component of final demand, either personal consumption, gross private fixed investment, exports, or government purchases,

ε_{ik} represents the elasticity for the i^{th} component of final demand for the k^{th} industry, and

F_{ik} represents the dollar value of final demand for the i^{th} component of final demand for the k^{th} industry.

Final demand for each I-O industry was calculated as the sum of the following four categories of final demand:[6]

- Personal consumption expenditures
- Gross private fixed investment (GPFI)
- Exports
- Government purchases.

Some combination of these different elasticities is appropriate for each of the 79 industries in the model, depending upon the composition of final demand. For example, in the electronic components industry (I-O 57), the final demands and the corresponding elasticities are the following:

[6]This definition of final demand c‹ ıld also be calculated as "Total Final Demand"- "Imports" (column 95) - "Change in Business Invent‹ ‹ies" (column 93).

Table C.1

Calculating Elasticities of Final Demand

Component of Final Demand	Final Demand Component/Total $		Elasticity
Personal Consumption Expensitures	1104/7492	x	1.1
GPFI	87/7492	x	0
Exports	5558/7492	x	1.2
Government Purchases	1743/7492	x	0
	Composite Elasticity		1.05

Therefore, the elasticity of final demand used in the remainder of the calculations for the electronic components industry is 1.05.[7]

COMBINING THE FOUR COMPONENTS

The final steps involve the actual computation of the defense metric which is repeated below.

$$\frac{p_i}{P_i} = \sum_j C_{ji} \frac{\sum_k C_{jk} d_k}{\sum_k C^2_{jk} e_k F_k}$$

This requires the three components described above: d_k, C_{jk}, ε_k, and a matrix $C^2{}_{jk}$ where each element is the square of the corresponding element of C_{jk}. The calculation was performed in a series of steps, some of which produce intermediate results of interest.

The numerator of the metric can be considered the increase in demand for the 479 occupations resulting from the increase defense spending from 1980 to 1983. The denominator of this fraction roughly represents the availability of workers in each occupation. This availability depends upon the number of workers in specific occupations, since an increase in demand of one thousand workers will have a greater impact on a small, highly specialized occupation than on a occupation with numerous members. In addition, the availability depends upon the category of final demand where the non-defense workers are employed. If all the workers in a particular occupation are employed in industries with low elasticities of demand, this would indicate that wages would have to increase substantially before the additional defense needs were met. On the other hand, if the workers are

[7]This process was repeated using different estimates for personal consumption and government purchases elasticities as described in Appendix B.

employed in industries characterized by high price elasticities for final demand, the expected wage increases would be more modest.

The entire fraction is an indication of the impact of spending on occupations, which takes into account both the increased demand created by defense spending, the number of workers involved in production for final demand, and the elasticity of final demand for the sectors where those workers are employed. The full metric is simply the weighted sum of the occupational impacts for each industry.

Appendix D

CONVERTING FROM INPUT-OUTPUT INDUSTRIES TO STANDARD INDUSTRIAL CLASSIFICATION INDUSTRIES

An additional conversion from the I-O to the SIC classification systems was necessary to measure industry trade performance. In this case, the 79 I-O industries were mapped into the 159 3-digit SIC industries. In most cases, this resulted in a one-to-many concordance, where a single defense-competing metric for each I-O classification would be applied to one or more SIC industries.

In some cases, the concordance was not easily accomplished. For example, in some agricultural industries, the concordance between I-O and SIC classifications is complex. In certain service industries represented in the I-O classification system, there are no relevant trade statistics. Fortunately, these problems are minimal in the conversion of the manufacturing industries from the I-O to the SIC classification systems.

Table D.1

Input-Output to SIC Concordance

I-O Code	I-O Title	SIC Code	SIC Title
32	Rubber and Misc. Plastics	301	Tires and Tubes
32	Rubber and Misc. Plastics	302	Footwear, Rubber or Plastic
32	Rubber and Misc. Plastics	303	Reclaimed Rubber
32	Rubber and Misc. Plastics	304	Hose and Belting
32	Rubber and Misc. Plastics	306	Plastic/Rubber Medical Supplies
32	Rubber and Misc. Plastics	307	Misc. Plastics Products
33	Leather Tanning and Finishing	311	Tanned and Finished Leathers
34	Footwear and other leather	313	Leather, Cut to Shape
34	Footwear and other leather	314	Footwear, Leather
34	Footwear and other leather	315	Leather Gloves
34	Footwear and other leather	316	Leather Luggage
34	Footwear and other leather	317	Handbags of Leather
34	Footwear and other leather	319	Misc. Leather Goods
35	Glass and Glass Products	321	Flat Glass
35	Glass and Glass Products	322	Glass or Glassware
35	Glass and Glass Products	323	Glass Products
36	Stone and Clay Products	324	Cement
36	Stone and Clay Products	325	Structural Clay Products
36	Stone and Clay Products	326	Ceramic Products or China
36	Stone and Clay Products	327	Concrete/Gypsum/Plaster Prods
36	Stone and Clay Products	328	Cut Stone or Stone Products
36	Stone and Clay Products	329	Abrasive Mineral Products
37	Primary Iron and Steel Mfg.	331	Steel Mill Products
37	Primary Iron and Steel Mfg.	332	Iron and Steel Products
38	Primary Non-Ferrous metals Mfg.	333	Refined Non-Ferrous Metals
38	Primary Non-Ferrous metals Mfg.	335	Rolled /other Non-Ferrous Metal
37	Primary Iron and Steel Mfg.	339	Primary Metal Products, nspf
39	Metal Containers	341	Drums, Cans or Boxes of Metal
42	Other Fabricated Metal Products	342	Cutlery and Saw Blades
40	Heating, Plumbing, and Fab. Metal Products	343	Heating Equipment
40	Heating, Plumbing, and Fab. Metal Products	344	Fabricated Structural Metal Products
41	Screw Machine Products, Stampings	345	Fasteners of Metal
41	Screw Machine Products, Stampings	346	Metal Forgings and Stampings
13	Ordnance and Accessories	348	Ordnance and Accessories
42	Other Fabricated Metal Products	349	Fabricated Metal Products, nspf
43	Engines and Turbines	351	Engines and Turbines
44	Farm and Garden Machinery	352	Farm and Garden Machinery
45	Construction and Mining Mach.	353	Construction & Oil Field Mach.
47	Metalworking Machinery	354	Metalworking Machinery
48	Special Industry Machinery	355	Special Industrial Machinery
49	General Industrial Machinery	356	General Industrial Machinery
51	Computers and Office Machines	357	Computers and Office Machines
52	Service Industry Machines	358	Refrigerators/Service Ind. Mach.
50	Misc. Non-Electrical Machinery	359	Non-Electrical Machine Parts
53	Electric Industrial Machines	361	Electric Distribution Equipment
53	Electric Industrial Machines	362	Electrical Industrial Apparatus
54	Household Appliances	363	Household Appliances
55	Electric Lighting and Wiring	364	Electric Lighting Equipment

Table D.1—continued

I-O Code	I-O Title	SIC Code	SIC Title
56	Radio, TV, and Commun. Equip.	365	Radio and TV Equipment
56	Radio, TV, and Commun. Equip.	366	Communication Equipment, nspf
57	Electronic Components	367	Electronic Components
58	Misc. Electrical Machinery	369	Electrical Machinery, nspf
59	Motor Vehicles and Accessories	371	Motor Vehicles and Parts
60	Aircraft and Parts	372	Aircraft and Parts
61	Other Transportation Equip.	373	Yachts and Pleasure Boats
61	Other Transportation Equip.	374	Railroad Equipment
61	Other Transportation Equip.	375	Motorcycles and Bicycles
13	Ordnance and Accessories	376	Missiles and Space Vehicles
61	Other Transportation Equip.	379	Misc. Transportation Equipment
62	Scientific and Controlling Instr.	382	Measuring & Controlling Instr.
63	Optical and Photographic Equip.	383	Optical Instruments
62	Scientific and Controlling Instr.	384	Surgical & Medical Instruments
63	Optical and Photographic Equip.	385	Opthalmic Goods
63	Optical and Photographic Equip.	386	Photographic Equipment
62	Scientific and Controlling Instr.	387	Watches and Clocks
64	Misc. Manufacturing	391	Jewelry and Silverware
64	Misc. Manufacturing	393	Musical Instruments
64	Misc. Manufacturing	394	Sporting Goods and Toys
64	Misc. Manufacturing	395	Pens, Pencils, & Artist's Materials
64	Misc. Manufacturing	396	Costume Jewelry
64	Misc. Manufacturing	399	Misc. Manufactured Products

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